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Annual Report of the

Board of Scientific Advice for India

for the year 1912-13

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CONTENTS.

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3. The Director, Geological Survey of India.

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1. The Director, Botanical Survey of India (Chairman);
2. *Vacant.*
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4. The Director, Geological Survey of India.

ANNUAL REPORT FOR 1912-13

ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

1912-13

SUMMARY OF PROCEEDINGS.

Twenty-fourth Meeting held at Simla on the 12th May 1913.

The Board agreed to nominate Mr. C. C. Calder, Officiating Director of the Botanical Survey of India, to officiate as Secretary to the Board during the absence of Major A. T. Gage, I.M.S.

The programmes of the various Scientific Departments for 1913-14 were considered and recommended for acceptance by Government. The Board considered that closer co-operation between the Pathological Entomologist and the Zoological Section of the Indian Museum seemed possible and was advisable in the interests of both Departments.

A letter from the Director of the Imperial Institute, London, on the subject of communicating the names of the investigators conducting scientific work at the Imperial Institute next came up for discussion. The arrangement suggested by Professor Dunstan was not considered altogether satisfactory. It was, however, tentatively accepted and it was suggested that all the Departments represented on the Board, when getting reports from the Imperial Institute, should ask to be supplied

confidentially with the names of persons who conducted the investigations on which the reports were based.

The Board accepted the recommendations of Sub-Committee A, that the Director of the Geological Survey should be regarded as the adviser to Government on seismological questions and that existing seismographs should remain under the control of the several departments that are now maintaining them.

Twenty-fifth Meeting held at Delhi on 12th November 1913.

The Board considered the question of an increased grant towards the upkeep of the Imperial Institute, London. The Board did not consider it desirable to commit themselves at present to a definite statement of further support, but left the matter open until more detailed information was available as to the present condition of the Imperial Institute collections and as to the probable utility of future work and exhibits.

The draft Annual Report of the Board for 1912-13 was considered and after a few minor alterations was approved as was also the revised distribution list of the Annual Report.

On the question of the relation between forests and the retention of atmospheric and soil moisture, a note was put up by the Director-General of Observatories, and on the representations embodied therein, the Board considered that the obstacles in the way of collecting reliable information and the expense involved more than counterbalanced the benefits which might result. They did not therefore recommend undertaking the enquiries at present.

Letters from the Chairman to the Trustees of the Indian Museum and a note by the Superintendent of the Zoological Section of the Museum embodying proposals for the constitution of a Zoological Survey for India were next considered. The Board viewed the constitution of such a survey with sympathy. They agreed in a general way with the proposals submitted, but thought that, in the event of such a scheme maturing, stress should be laid on the relations which were to subsist between the Directorship of the Survey, the Superintendentship of the Museum and the Secretaryship to the Trustees. They did not consider it desirable to lay down as a fixed principle that the Director of the Zoological Survey in particular should continue to be Secretary to the Trustees or Superintendent of the Indian Museum, though he should necessarily in the opinion of the Board be in charge of the zoological collections of the Museum.

APPLIED CHEMISTRY.

PART I.—ECONOMIC AND INDUSTRIAL CHEMISTRY.

BY

D. HOOPER, F.I.C., F.C.S., F.L.S.,

Economic Botanist, Botanical Survey of India.

The following is a review of the chemical work conducted during the year 1912-13 irrespective of that undertaken by the Agricultural and Forest Departments of India. There is very little to record on the subject of inorganic chemistry and the present report deals almost exclusively with substances of vegetable origin examined in India and Europe. As usual a considerable amount of research has been prosecuted by professors and students in the universities, and the titles of the published papers which are not, however, directly concerned with industrial chemistry have been included in the bibliography. Where the author's name is not quoted in the following investigations the work has been carried out in the laboratory of the Industrial Section of the Indian Museum, Calcutta. This laboratory, it may be stated, was closed during the year under review.

The material has been arranged according to the following classification:—

1. Natural exudations : gums and resins.
2. Fixed and volatile oils.
3. Dyes and tans.
4. Fibres and paper.
5. Food substances.
6. Drugs.

I.—Gums and Resins.

Sarcocolla gum.—This is one of the most peculiar natural exudations of plants. Exuding from a shrub identified as *Astragalus fasiculifolius*, Boissier, growing in Persia, it is largely exported to Bombay and is used in medicine and for adulterating opium. It is sweetish to the taste and dissolves for the most part in alcohol and in water. It is not a true gum resin or gutta, but consists principally of a glucoside, sarcocollin which differs in properties from saponin and glycyrrhizin.

Balsamodendron Playfairii.—This shrub growing in the Somali Coast yields a peculiar soapy gum called "Hotai" which is

sent in large quantities to Bombay. It disintegrates in water forming a persistent lather and is used for washing the hair. It contains an acid resin soluble in ether and saponin. The occurrence of saponin in a natural exudation is peculiar. Another substance of a similar nature was collected on tour in Karachi. This is called "Dakh" and is brought from the Mekran Coast, Persian Gulf, and is also used by women for washing the hair. It differs from the first named in appearance and composition, but contains a resin and saponin as its principal constituents.

II.—Fixed and Volatile Oils.

Cotton seed.—Progress is being made in the cotton seed oil industry judging from the number of mills that have been established during the past few years. The Director General of Commercial Intelligence has sent for examination samples of refined oil, decorticated cotton seed cake and hulls. These were found to have a good appearance and quite up to the standard in composition of similar products in the European and American markets.

Soy beans.—Experiments are being continued in the cultivation of soy beans in Northern India. The habits of the plants and the character of the seeds are so various that some care has to be exercised in selecting suitable sites for the different varieties. The Superintendent of the Government Gardens, Kumaon, planted Hollybrook soy beans at Douglas Dale and Ramgarh. Analysis showed that the seeds grown in the first locality gave 18·26 per cent. of oil and those grown at the second locality gave 14·26 per cent. Also samples of gun bean grown at Douglas Dale yielded 18·66 per cent. of oil and when grown at Ramgarh yielded 15·74 per cent. The Director of Land Records and Agriculture, United Provinces, sent samples of the same kind of soy bean grown in four different villages: they afforded 14·3, 12·2, 12·6 and 11·6 per cent. of oil.

Papaw seeds.—The seeds of the ripe fruit of Papaw (*Carica Papaya*) which are usually thrown away as useless were submitted to analysis. The small black seeds have a pungent mustard-like odour and yield an allyl compound when distilled with water. They contain over a quarter of their weight of a yellow fixed oil. The centesimal composition is: water 8·2; oil 26·3; albuminoids 24·3; carbohydrates 15·5; fibre 17·0; ash 8·8.

Litsæa polyantha, Juss.—This is a small evergreen tree met with from the Punjab along the foot of the Himalayas eastwards to Assam. The seeds yield an oil which is used medicinally. A sample of the fruit from Golaghat, Assam, was examined. The cleaned seeds yielded 21·2 and the kernels 33 per cent. of a white crystalline fat,

melting at 38·5°. The constants were: acid value 98·9; saponification value 244·8; iodine value 34·4. The fat is of a useful nature and consists very largely, like that of other Litsæas, of lauric acid.

Nephelium Longana, Camb.—This is the Longan or Ashphal, the fruit of which appears in India in the hot weather. The fresh fruit afforded 13 parts of skin, 60 parts of pulp and 27 parts of seeds in 100. The seeds which are a waste product are sweetish and slightly astringent and contain much starch. Chemical analysis showed them to contain: moisture 10·0; oil 3·86; albuminoids 6·25; carbohydrates 73·76; fibre 3·6; ash 2·5. They are not oil-seeds, but the composition shows them to have a feeding value equal to that of cattle foods.

Tea seed oil.—This oil has once more been examined, this time by Mr. A. K. Menon from kernels obtained from Tinsukia, Assam. Petroleum ether extracted 16·1 per cent. of a clear straw coloured oil which deposited solid fats on standing. The oil had the following characters: specific gravity 0·9028; acid value 3·75; saponification value 189·9; Reichert Meissl value 0·56; iodine value 92·7; unsaponifiable 2·65. The solid fatty acids melted at 57·8° and had the mean molecular weight of 267·3.

Cydnus indicus oil.—This common black stink bug of India has been examined by Mr. E. R. Watson. The strong and unpleasant odour of the insect is due to an oil which it secretes. The oil has been found to contain a large proportion of non-volatile oil of the same character as other animal oils. It also contains about 1·5 per cent. of an oil volatile with steam consisting of an acid $C_8H_{14}O_2$, probably cycloheptanecarboxylic acid and a small quantity of a non-acid substance. The acid has a strong rancid odour and the non-acid volatile substance has a still stronger odour.

Artemisia vulgaris, Linn.—Indian Wormwood oil from Lebong, Darjeeling. The colour is yellowish with a greenish fluorescence and an odour of sage. Examined by Messrs. Schimmel & Co., it was found to be soluble in one vol. of 80 per cent. alcohol. When more than five vols. was added, opalescence ensued and after prolonged standing paraffin crystals separated out of the solution, with semicarbazidethujone melting at 186° separated from oil. From the odour of the oil it probably contains borneol.

East Indian bees'-wax.—Messrs. Buchner and Fischer have published the results of analyses of a large number of samples of East Indian bees'-wax or "Ghedda" wax. The wax is derived from *Apis indica*, *A. dorsata* and *A. florea*, and differs widely in composition from ordinary bees'-wax, chiefly the product of *A. melifica*. The wax gives abnormal analytical figures in that the ratio between the acid value and the ester value is 12 or higher, and the wax contains glycerides and

neutral substances which might from analytical data be mistaken for ordinary bees'-wax containing adulterations. The results confirm those arrived at by Mr. Hooper who described the sources and composition of Indian bees'-wax in Agricultural Ledger No. 7 of 1904.

III.—Dyes and Tans.

Cotton flowers.—A. G. Perkin has investigated the colouring matter of Indian cotton flowers (*Gossypium herbaceum*) and finds it to be due to gossypetin and quercetin. Gossypetin is also present in the flowers of Egyptian cotton and *Hibiscus Sabdariffa*. The formula is $C_{15}H_{10}O_8$. Fused with alkali it gives pyrocatechuic acid and on oxidation it affords gossipitone in dull red or maroon coloured needles which proved to be a quinone.

Tagetes patula.—Mr. Perkin has also examined the flowers of the African Marigold grown in India. Quercetagin was isolated from the flowers by Latour and Magnier de la Source (*Bull. Soc. Chem.*, 1877, 28, 33) who gave it the formula $C_{27}H_{22}O_{13}$. Perkin finds that the main quantity of the colouring matter is present in the petals as a glucoside, and the colouring matter itself $C_{15}H_{10}O_8$ was isolated from this. It yields protocatechuic acid on fusion with alkali. It is a hexahydroxyflavonol isomeric with myricetin, but differs from this colouring matter and also from the closely allied quercetin in that it possesses a tetrahydroxy-benzene in place of the phloroglucinol nucleus which they contain.

Azo-salicylic acid dyes.—Messrs. A. C. Sircar and E. R. Watson have contributed two papers on Azo dyes to the Society of Chemical Industry. Azo-salicylic acid dyes in chrome mordants have excellent fastness to light. There is a marked difference between the derivatives of a hydroxy-naphthoic and 2·3 hydroxy-naphthoic acids, the derivatives of the former being all fugitive, whilst the majority of the derivatives of the latter have very good fastness. All the dyeings have excellent fastness to acids.

Cæsalpinia digyna.—Mr. T. A. Faust has given the results of experiments with tan pods, from a bush growing wild in Burma and Assam. The pod cases contain as much as 60 per cent. of tannin, and the leather produced by the material is equal in colour to that made from the best sumach. Colour tests in sheep skins were made with solutions of the entire pods and pod cases; the former did not give a uniform colour owing no doubt to the oil in the beans, but the latter gave leather of a light uniform colour. The light colour of the leather tanned with the material was very little darkened by exposure to light for four weeks in which respect the material shows an advantage over allied products of the same class. It would not be profitable for the tanner

to separate the seeds; the pods, however, could be leached whole as the tannin in the cases is extracted very rapidly and the oil in the seeds would not be removed. The material could be obtained at about £9 10*s*. per short ton, which price compares favourably with that of other materials of the same tannin strength.

Cassia auriculata or Turwar bark.—The analysis and uses of this South Indian tanning material has formed the subject of a paper by Mr. P. V. Mehd. The maximum amount of tannin in the bark was 22·1 per cent. and experiments were made with this and myrobalans on English hide. It is concluded that though Cassia bark may not be suitable for fancy leather goods and leather for book-binding, it may be used with advantage for heavy as well as for dressing leathers, giving, when blended with myrobalans, a mellow tannage, a very good, light-coloured leather, which compares favourably with that produced by any of the other blends at present in common use.

Adulterated leather.—In connection with this subject Mr. M. C. Lamb has contributed a paper before the Society of Public Analysts on the analysis of various East Indian tanned hides. The analysis of about sixty samples obtained from reliable sources of various tannages of East Indian hides were made with the object of ascertaining what particular tannages are most liable to adulteration by the addition of mineral matter and oil. The results of the various analyses are given in detail and show that the amount of adulteration suspected in these imported tanned hides is not nearly so prevalent as is generally anticipated and understood by the trade.

IV.—Fibres and Paper.

Hedychium fibre.—Among the sources of supply for the manufacture of paper Messrs. Beadle and Stevens have conducted factory experiments on *Hedychium coronarium*, Koenig., a plant of the ginger tribe. This plant is a native of India and is distributed from the Himalayas to Ceylon and Malacca, ascending to 4,000 feet in the Khasia Hills. It grows abundantly in Brazil where its growth is easily developed. If properly cultivated it yields from 6 to 10 tons of dry material per acre, a quantity much larger than other paper-making materials, including bamboo and wood pulp. The papers prepared from *Hedychium* fibre are among the strongest hitherto recorded, equal or superior to the best manila papers, and are particularly suitable for the manufacture of paper yarns for textile purposes. It is an easy pulp to manipulate and can be worked either bleached or unbleached. The fact that the paper in its natural state, without the addition of any materials whatever, can be made to possess grease-proof and self-sizing qualities is a point of commercial importance. Other plants of the same natural order are *Amomum hemisphericum* and *Alpinia nutans*, and these have been

found to possess the natural advantage of Hedychium and more suitable for the manufacture of white paper made from strong sulphite wood pulp.

In this connection a plant received from Assam as growing in large quantity and known as "Adurantum" has been tested. It was identified as *Plecanthus Wightii* of the nettle tribe, and yielded 33·6 per cent. of strong white fibre.

V.—Food Substances.

Edible roots.—The Director of Agriculture and Industries, Central Provinces, collected and forwarded to the Indian Museum an interesting series of tuberous roots eaten by the inhabitants. Some of these being supported by botanical specimens, were identified and found to be new to economic botany. Chemical analyses were made of the more important.

The list included the following:—*Hibiscus* sp. Ban bhendi or Khapsi kand. *Pynocycla glauca*, Linn. Tejraj. *Peucedanum Dhana*, Ham. Kamraj. *Peucedanum glaucum*, DC. Bhojraj. *Eulophia* sp. Bansinghara. *Habenaria platyphylla*, Spreng. Chilam chatta.

The *Hibiscus* root is very mucilaginous and fairly nitrogenous. *Pynocycla* and *Peucedanum* roots belong to the same order as the carrot and are as palatable. The Eulophia and Habenaria roots of the orchid family afford salep which has long been a favourite dish with certain classes.

VI.—Drugs.

Atropa Belladonna, Linn.—It was shown last year that the roots of belladonna plants grown at the Kumaon Botanical Gardens yielded 0·4 per cent. of alkaloid when one year old and 0·45 when two years old. A sample of roots from three-year-old plants was received this year and was divided into thin and thick roots. The former yielded 0·4 per cent. of alkaloid and the latter 0·44 per cent. showing that the root does not increase in alkaloidal content after the second year.

The leaves of belladonna grown in the same gardens were also examined. Leaves from one, two and three-year-old plants afforded 0·48, 0·49 and 0·49 per cent. of alkaloid respectively. This result indicates that leaves from plants of different ages do not show much variation in composition.

Glycyrrhiza glabra, Linn.—A sample of liquorice root grown in Baluchistan was tested for solid aqueous extract. This amounted to 27·75 per cent. which is well above the pharmacopœia limit of 20 per cent.

Calotropis procera.—Dr. L. Lewin has made a chemical and physiological examination of this common Indian plant. He finds the

active principle, which he designates calotropin, to belong to the class of drugs which act on the heart like *Digitalis*. The substance was not obtained pure for chemical analysis.

Digitalis purpurea.—The Foxglove is cultivated on the Nilgiri Hills and the dried leaves have for some years been supplied to the Medical Stores at Madras for the manufacture of official preparations. Digitalis leaves used in Europe are standardised before being used in medicine. A sample of the Indian grown leaves has during the year been sent to London for this purpose, and it is satisfactory to know, from a report received from Dr. W. Harrison Martindale, that the Indian leaves are equal in medicinal activity to those grown in England.

Euphorbia pilulifera, Linn.—This is one of the indigenous drugs of India and is a popular remedy for a great variety of affections. Dr. Power and Mr. Browning have submitted the plant to a complete chemical examination. The authors separated the following constituents: essential oil, gallic acid, a new phenolic substance, an amorphous glucoside, a lævorotatory sugar, a trace of alkaloid, triacontane, euphosterol, a new monohydric alcohol, a phytosterol, a phytosterolin, jambulol, melissic acid, and a mixture of acids which appeared to consist of palmitic, oleic and linolic acids. Among the various constituents there is none to which any specific physiological action may be ascribed. Such therapeutic virtues as the plant has been presumed to possess would therefore not appear to depend upon any single substance of a definite chemical character.

Gymnosporia manna.—Messrs. J. R. Furlong and L. E Campbell have described a new variety of manna obtained as a white encrustation on *Gymnosporia deflexa*, Sprague. The chief constituent of the manna was dulcitol melting at 188° C. It is interesting to notice that in 1909 Mr. Hooper obtained dulcitol from an encrustation on *Elaeodendron glaucum*. In the latter case the manna was the secretion of an insect *Phromnia marginella*. It is probable that this or some allied insect agency is responsible for the deposit of a saccharine exudation on Gymnosporia as it is on other trees of the natural order Celastrinaceæ which have been found to contain dulcitol. It has been suggested that the Phromnia insect should be encouraged to propagate on plants of this order for the purpose of producing dulcitol on a commercial scale.

Teak wood.—Following up the researches made some years ago by Dr. Romanis of Rangoon, Mr. A. C. Sircar has investigated a possible chemical method of distinguishing between seasoned and unseasoned teak wood. The author finds that teak wood saw-dust yields on steam distillation either a crystalline or oily substance or a mixture of the two, the amount of the former as compared with the amount of the latter being a criterion of the amount of seasoning of the sample of wood

examined. The crystals melted between 156° and 160° without decomposition.

Entada scandens.—Mr. F. T. Eddingfield has investigated the peculiar use in the Philippine Islands of the bark of Gogo (*Entada scandens*) and its effect on gold and gold solutions. It is used by the natives for panning gold-bearing sands, and it is believed that by its use more gold is recovered by causing the fine gold to settle quickly and not float away. The aqueous solution of the bark contains saponin which forms colloidal gold with a purple solution. Apparently its only agency is the effect of the solution falling on the floating particles of gold in the pan and causing them to sink.

Plant ashes.—Several analyses were made during the year of plants ashes having a special reputation for industrial purposes. The ashes of the following plants were tested:—Wormwood (*Artemisia vulgaris*), Bamboo (*Bambusa* sp.), Papaw leave (*Carica Papaya*), Plantain leaves (*Musa sapientum*), Wild Date (*Phœnix paludosa*) and Saltwort (*Suæda maritima*). The ash of the plantain was made a special study, since it has long been used in India as an alkaline mordant, by dhobies in place of soap, by doctors as a medicine, as a crude form of table salt and as a manure. It was therefore considered worthy of enquiry to examine samples of the ash of this plant to discover if they possessed any uniformity of composition and an alkalinity superior to that of other plant ashes. Museum samples were found to have a water soluble extract ranging from 7·94 to 27·51 and insoluble silica from 22·2 to 52·04 per cent. The ash of sample of leaves collected and ignited under supervision were next tested, but these showed striking differences in composition and no single element existed in a constant proportion. The lime, potash and phosphoric acid have a certain value in agriculture and the alkali is useful as a mordant and for detergent purposes, but there is no standard composition peculiar to the plant.

PART II.—AGRICULTURAL CHEMISTRY.

BY

J. WALTER LEATHER, V.D., Ph.D., F.I.C.,

Imperial Agricultural Chemist.

SOILS.

The gases of swamp rice soils.(*i*)—An important series of experiments has been in progress during the last four years at the hands of Messrs. Harrison and Subramania Aiyar in Madras on the composition of the

(*i*) Memoir, Department of Agriculture in India, Chemical Series, Vol. III (*in the press*).

gases which are included in the wet paddy lands of certain parts of south India, which together with the biological examination will add very much to our knowledge of the *raison d'être* of the agricultural practice and in places assist in its improvement. The agricultural practice of paddy cultivation varies a good deal in different localities, but frequently it consists in the following sequence of operations; (*i*) admission of water to the land, ploughing, addition of green leaf manure and puddling of the surface layer of soil, (*ii*) removal of the surface water, (*iii*) transplanting the young rice, (*iv*) re-admission of irrigation water after the seedlings have established themselves, and which water is maintained on the land until the crop is nearly mature, (*v*) removal of the water from the land in order to allow the plant to dry up and be harvested.

After the ploughing-in of the green manure, a good deal of gas is formed in the soil and the composition of this gas forms the subject of the first part of the memoir. After the paddy is transplanted and has become established, a film forms on the surface of the muddy soil, which materially affects the composition of the soil gases which reach it. Its character and functions form the subject of Part II.

Restricting the attention to the nature of the gases formed in the soil, these are separated by disturbing the mud. Samples of these gases were obtained by carrying a gas collecting apparatus of suitable design across the field; as the feet disturbed the mud, the released gases passed into the collector. They consist chiefly of nitrogen and methane, and the following examples taken from the numerous ones which the memoir contains will sufficiently illustrate the composition:—

Methane	73·8 %	64·4 %
Nitrogen	10·9	20·1
Carbon dioxide	14·6	3·0
Oxygen	·7	1·0
Hydrogen	*Nil.*	11·5

After the paddy has been transplanted and has become established, the character of the gas mixture changes, the proportion of methane markedly decreases, whilst that of nitrogen increases, and hydrogen production becomes largely inhibited. Thus we find:—

Methane	16·6 %
Nitrogen	78·8
Carbon dioxide	4·4
Oxygen	·2
Hydrogen	*Nil.*

Measurements were made of the relative amounts of gas present in cropped and uncropped land respectively which showed a slightly

greater proportion in the cropped land, though the disparity was not large and the method employed for the purpose was not considered very reliable. The importance of this relationship lies in the fact that (*i*) if less gas is evolved from cropped than from uncropped land, then the production of methane is being interfered with, whilst (*ii*) an increased gas production from cropped land would imply an increased evolution of nitrogen. The question was therefore investigated by means of pot cultures.

It must here be mentioned that when making these cultures it was necessary to stop the formation of the organised surface film, to which more complete reference is subsequently made, because of its complicating influence. Its formation was inhibited by means of a small addition of copper sulphate to the water. Under these restricted conditions, the production of methane progressed until after the paddy seedlings were planted in the jars, when its formation ceased entirely. Concurrently there was a marked decrease in the amount of nitrogen gas evolved. Other measurements showed that manured land produced about three times as much nitrogen as unmanured land. The action of the crop is to restrict the formation of methane and hydrogen either by retarding the rate of fermentation or by a portion of the intermediate products of decomposition being absorbed by the roots. There is also evidence to show that the normal evolution of nitrogen is retarded in a similar manner.

In the ordinary course of events in the field, a film forms on the immediate surface of the mud which varies in different localities, but includes diatoms, usually algæ, and bacteria. It plays the important rôle of an oxygen generator. The quantity of this gas which is formed daily is very considerable, and usually rather greater in the absence of a crop. These processes continue either in the presence or in the absence of manure, but the presence of manure increases the production of oxygen considerably. The roots of the rice plant require oxygen, which is carried from the site of its formation by the surface film in the decending water to the root system, and thus becomes available to the plant.

The authors carried out a series of pot cultures to ascertain the rate at which drainage should pass through paddy land, for it is evident that such descent of the upper water must take place if the above mentioned oxygen is to pass below. These tests showed that the downward movement must be slow. If too rapid, harm resulted. We have thus a fairly good picture of the series of changes which occur:—decomposition of organic matter, utilisation of some of the products of this decomposition by an organised surface film, production of oxygen, transport of this oxygen to the soil by the descending water for the use of the plant roots.

This valuable research appears to have already borne practical fruit, for the Report of the Director of Agriculture,(*ii*) Madras, refers to cases where green manuring has been a failure and which failure is probably explained by an absence of proper drainage, which Messrs. Harrison and Subramania Aiyar have shown to be so desirable.

The investigations are naturally not yet considered by the authors to be complete and are being prosecuted.

WATER.

Evaporation from a plane water surface.—As an accompaniment of the estimations of the water requirements of crops which have been conducted by Dr. J. W. Leather at Pusa for some years, the amount of evaporation from a plane water surface was measured for about three years and the data for 1911 and 1912 have been published.(*iii*) The water surface was provided by a masonry tank 6′ 6″ diam.; the position of the water surface was measured by means of a pointer, which travelled along a groove on a vertical iron pedestal; the distance through which it travels was measured by means of a small wheel travelling along a screw. Differences of ·015 cm. were readily registered. The amount of water percolating through the tank was tested by covering the surface with vegetable oil and was found to be barely measurable in five days and was therefore negligible. The tank was protected from animals by means of wire netting.

The amount of water which evaporated at Pusa was compared with records which have been maintained at Lyallpur by the Irrigation Department and at the Madras Observatory. During the cold weather the daily evaporation at Pusa is very similar to that at Lyallpur, both of which are less than at Madras; during the hot weather it is greatest at Lyallpur and least at Pusa. The total annual evaporation at the three stations was found to be:—

Lyallpur	6·42 ft.
Pusa	4·12 „ (1911).
Do.	4·18 „ (1912).
Madras	6·34 „

An empirical formula was deducted from the Pusa and Lyallpur data. E= (mm. per 24 hours) =2·0 (log t—1·74) + ·33 (log D—1·00) + ·36 (log W—·125)

in which

t=mean temperature ° F. for day.

D=100 minus 8 A.M. humidity.

W=mean wind velocity for day.

(*ii*) Report on the operations of the Department of Agriculture, Madras Presidency, for 1912-13, page 5.

(*iii*) Memoir, Department of Agriculture in India. Chemical Series, Vol. III, No. 1.

This formula yields fairly correct results and depends on meteorological data which are published for many places in India.

SUGAR.

The experimental error in sampling sugarcane.(*iv*)—The more systematic sampling of crops has been examined of late years. Until recently the subject had not been examined mathematically, and the taking of a sample to represent a plot or a field was a matter of the fancy of the operator. Some four years ago Dr. J. W. Leather decided to examine the subject in relation to sugarcane at Pusa in order to ascertain what size of sample must be considered necessary, and in what manner it should be taken, in order to reduce the error to certain limits, and to ascertain what those limits may be expected to be.

The first two seasons' work did not yield very satisfactory information, but this year when the tests were conducted on a different system, a much more definite answer to the questions was arrived at.

It was found that the variation among individual canes all growing contiguously was very great indeed, so much so that some 200 had to be tested before the error from the mean value was reduced to small dimensions. It was anticipated in view of the generally accepted ideas in regard to effect of soil, that if a similar number of canes were taken from points distributed all over a plot of say $\frac{1}{10}$ acre, and still more so if they were taken from over a whole acre, this error would be found largely increased. In the event, however, this was not found to be the case; the variation seems to be but little greater on a large than on a small area. The work was conducted not only at Pusa, but also at the Parsa Factory in the north of Champaran district, and the results agreed well at both places.

Duplicate samples of about 200 canes taken in a well distributed manner showed that the probable error from the mean may be depended on to be not more than $\pm$·5 per cent. sucrose in 995 cases in 1,000. If, however, the size of the sample is reduced to about 50 canes, taken in the same manner, the error was found to rise to about $\pm$2·0 in 5 out of 1,000 cases. The canes must of course be taken from all over the area in any case.

Date palm sugar.—A valuable contribution to our knowledge of the date palm sugar industry has been published during the year,(*v*) the author being Mr. H. E. Annett. The survey and experimental work which he carried out relates chiefly to Bengal. The history of the industry shows that it expanded rapidly in the middle of the last century, but since then it has shown signs of declining somewhat.

(*iv*) Memoirs, Department of Agriculture in India, Chemical Series, Vol. III (*in the press*).

(*v*) Memoirs, Department of Agriculture in India, Vol. II, No. 6.

The source of supply in Bengal is almost exclusively *Phœnix sylvestris;* whereas in Madras and Burma *Borassus flabelliformis* chiefly takes its place. Other palms which play a smaller part are *Cocos nucifera* and *Caryota Ureus* in Madras, and *Nipa fruticans* in Eastern Bengal and Burma. Mr. Annett's investigations had to do almost exclusively with the first named, *Phœnix sylvestris.*

The trees are first tapped at an age of 5 or 6 years; the trunk is then about $1\frac{1}{2}$ feet high. Tapping consists in (*a*) the removal of all but the top young leaves from one side of the tree, (*b*) the removal of most of the soft tissue which overlies the sap-supplying inner zone, (*c*) removing, after an interval of some 8 days, a further portion of the outer tissues and (*d*) finally, after a further interval of some 12—14 days, incising into the sap-tissue. The flow of juice is usually taken three nights in succession. It decreases in quantity and frequently in quality on each of these occasions. These succeeding juices are therefore distinguished from one another under the terms "jiran," "dokat," "tekat." After an interval of a further three days, a fresh wound is made and juice again taken for usually three succeeding nights. The tapping season continues from November until sometime in March, the production of juice being greatest during December-January. Mr. Annett estimates the yield of juice per tree per season to be about 170 lbs.

The sugars in the juice were carefully examined and only sucrose and glucose were found. The amounts vary considerably; of sucrose the percentage was found to be as high as 17 per cent. and as low as 7·5 per cent. in the "jiran" juice, whilst it falls as low as 5 per cent. in the "tekat." The proportion also varies in the juice of the same tree a good deal during the night. The proportion of glucose likewise varies within wide limits, being as small as ·3 per cent. and as high as 2 per cent.; great difficulty is, however, experienced in obtaining juice which has not suffered inversion to a certain extent. One of the difficulties of the industry in fact consists in the exposure of the juice to the influence of yeasts and other organisms which commonly cause a serious loss of sucrose. The usual practice is to smoke the pots in which the juice is collected on the tree. This matter formed a subject of special enquiry at Mr. Annett's hands, and will no doubt be taken up by him again, since the protection of the juice in this respect would lead to a considerable improvement in the quantity and quality of the sugar obtained.

Apart from this extraneous influence, both the yield and composition of the juice are affected by other factors. The general atmospheric temperature is one, the greatest yield being obtained during the two coldest months December and January, and any sudden rise of temperature causes a decline; cloudy or rainy weather also causes a decline in the flow. The individuality of the tree, as might be expected, is an important

circumstance and the thickest trees were found to be the best. The effect of soil was not definitely traced, though local opinion favours a clay rather than a sandy soil.

The pots are collected from the trees in the morning and the collected juice boiled down to the consistence of "Rab." Mr. Annett estimates the yield of *gur* per tree per annum at about 21·25 lbs. Calculated to the acre the produce equals some 2·3 tons. During the manufacture of the *gur* there are necessarily some losses of sugar in the same manner as there are in the case of cane juice; these are estimated at about 12·5 per cent.

The refining process is conducted by *Khandsaris* who purchase the *gur* (rab) through middlemen. The earthen pots containing the "rab" are broken and the contents put into large baskets of about $2\frac{1}{4}$ maunds capacity. From these the liquid molasses run off for 3—4 days, after which the sugar is overlaid with wet weed, *Vallisneria spiralis,* which purifies the uppermost layer of sugar in the same way as the weed "sewar," *Hydrilla verticilata*, purifies cane sugar in Rohilkhand. The refined sugar contains from 94—98 per cent. sucrose.

INDIGO.

The newly issued report(*vi*) of the investigations which have been in progress at Sirseah for some years is the last that will appear; it having been decided to conclude that work. Although this course has been decided upon, the report is more than usually interesting. Its subject matter may be conveniently referred to under the following heads:—

Physiology.—Efforts have been made to trace a connection between compounds present in the seed and during germination with the indican of the leaf. These failed. The seeds of *Wrightia tinctoria* and *W. tomentosa* both contain indican; the leaves of the former also contain indican, but those of the latter contain none. No other indigo-yielding plant contains indican in its seed. Moreover, it was not found possible to form indoxyl or any derivative of indoxyl from compounds present in the seed of any of the *indigoferas*.

Experiments were made in the hope that by the aid of stimulants the proportion of indican in the leaf might be increased. Some experiments made in 1908(*vii*) had given rise to a hope that such a result was possible, but no success followed an extension of the experiments.

Other indigo-yielding plants.—A large collection of indigo-yielding plants was made and one of these, *Wrightia tinctoria*, as mentioned

(*vi*) Report of the Indigo Research Station, Sirseah, for 1912-13 by Cyril Bergtheil and F. R. Parnell. Published by Bihar Planters' Association.

(*vii*) Annual Report, Board of Scientific Advice, 1908-09, p. 21.

in last year's report(*viii*) gave some promise of being useful. The leaf yields about ·3 per cent. indigotin. Manufacture of the dye carried out on the laboratory scale (all that the then present supply of plant admitted) indicated that about 9 seers of 60 per cent. indigo might be obtained per acre at one cutting. It is a perennial shrub and several cuttings might be expected per season. A difficulty attending its use is the requirement that a relatively high temperature of the steeping water—104° F.—must be maintained for 12 hours. The explanation of the necessity for this temperature was not ascertained.

Seed supply.—Although this matter has nothing to do directly with the chemical side of the work, it cannot be left altogether unnoticed. It has transpired that a great deal of indigo seed has been coming from Sukkur. The variety of *I. Sumatrana* grown in the neighbourhood of Sukkur is known to yield a very low quality of plant from the manufacturer's point of view, and its disadvantages are obvious.

Indigo paste.—A quantity of indigo was sent to Europe in the form of paste and reported on favourably by dyers. It was also tested at the Cawnpore Woollen Mills and there found to equal the synthetic paste, the two being tested on a basis of equal amounts of indigotin.

Selection and plant breeding.—The second part of the Sirseah Report deals with Mr. Parnell's share of the work of the last four years. His problem was to ascertain whether the plant could be improved in respect of its indigo-yielding power by either selection or hybridisation.

A close study of the morphological characters and the indigo yield showed there was no simple correlation, and it followed that the valuation of every plant must depend on its chemical analysis. It is necessary to realise this and also the circumstance that the chemical test in any one case is a somewhat time-absorbing matter, because it explains that the progress of such work must be a slow one. Another controlling factor is the duration of each generation. The Java plant was worked on chiefly because it seemed to offer a better promise of encouraging results. It is sown in September-October; the plant flowers at the same period of the following year and the seed comes ripe in the succeeding February. Thus two years must elapse before the seed of the second generation is planted.

Commencing in 1910, 235 plants were selected and analysed; the seed of these was expected in the following February. Unfortunately inordinately high floods visited Sirseah and the whole of these plants were destroyed. In 1911, 555 plants were analysed; but misfortune again followed; the disease, which has recently taken such a hold of the

(*viii*) Annual Report, Board of Scientific Advice, 1911-12, p. 30.

indigo plant in Bihar, attacked and killed nearly the whole of these plants.

Whether the proportion of indican in the leaf is chiefly controlled by the inheritance factor is still doubtful, but the curves published in the report show that it is at least possible, and it is much to be regretted that this part of the work should have been brought to a conclusion before it was in the least degree possible to provide an answer to this very important question.

BETEL VINE LEAVES.

A contribution to the knowledge of the chemistry and physiology of the leaves of the betel vine—*Piper betle*—has been made by Messrs. Mann, Sahasrabuddhe and Patwardhan.(*ix*) Although this leaf is consumed so widely in south-east Asia and universally in India this investigation seems to be the first attempt to ascertain its chemical composition and to detect any characteristic compounds. Leaves were examined from different parts of the vine.

Sugars.—Both reducing and non-reducing sugars were found, though not identified; the quantities were 1·5 to 3·0 per cent. of each class; usually there is rather more of the former than of the latter. *Starch* was found in the proportion of approximately 1·0 per cent. *Essential* oils varied only slightly and were present to the extent of about 1·0 to 1·5 per cent. *Tannins* varied from 1·0 to 1·3 per cent. The leaves are slightly acid and contain compounds possessed with diastatic activity, the younger leaves containing the most. *Potassium nitrate* was found in all leaves and also in the stems in comparatively large amount, from 1·0 to 4·0 per cent. of the dry substance, which is a most unusual circumstance in plant life.

Bleached leaves.—An adjunct to the betel leaf industry is the bleaching of the leaves, these bleached leaves commanding a price about three times as great as the ordinary green leaf. Curiously this special industry has never been described in English literature and the authors provide this in the memoir. The process is briefly as follows: The fresh green leaves, in quantity about 50—70 lbs. weight, are packed carefully edge downwards in a circular basket, and at the same time are moistened. Periodically at intervals of every few days the leaves are removed and examined; decayed ones are thrown out, bleached ones removed for sale, and green sound leaves replaced. In experiments conducted by the authors, about 50 per cent. of the leaves bleached, and the greater part of the other half were decayed and useless.

During the bleaching it was found that the amount of essential oil increased from 1·0 to about 4·0 or 5·0 per cent.; the acidity also increased;

(*ix*) Memoirs, Department of Agriculture in India, Chemical Series, Vol. III, No. 2.

the starch and non-reducing sugars decreased; the nitrate remained constant. Experiments were made by exposing small numbers of leaves to the action of various vapours and these indicated that the bleaching process is one of oxidation in acid solution; anything in the nature of an alkali causes rotting of the leaf.

PHYTIN AND PHYTIC ACID.(x)

With a view to a more exact knowledge of the organo-phosphorus compounds in seeds, Mr. G. Clarke has separated phytin and phytic acid from field mustards, and has described them. The ultimate object in view is additional means of bringing the properties of certain seeds into comparison with one another.

PART III.—FOREST CHEMISTRY.

BY

PURAN SINGH, F.C.S.,
Forest Chemist.

The following is a brief account of the more important work carried out by the Chemical Department of the Forest Research Institute during the year under report:—

Burma Myrabolans.—Nineteen samples of Myrabolans collected in different localities in Burma were analysed with the object of comparing their tannin value with that of Myrabolans grown in India. The tannin content of the fruit-pulp was found to vary from 19 to 22 per cent., only two samples showing 34 per cent. Thus the Burmese Myrabolans appear to be 50 per cent. poorer in tannin than those grown in India, the average tannin content of which is about 50 per cent. The Burma Myrabolans also give darker coloured tan liquors which contain four to five times more red and five to six times more yellow than do the liquors prepared from Indian Myrabolans. It is therefore doubtful whether the tree known as *Terminalia Chebula* in Burma is botanically identical with the Indian tree of the same name. The attention of the Forest Botanist has been drawn to this point with the object of deciding the botanical identity of the trees. If they prove to be identical, the factors of the locality, etc., influencing the tannin-content of the fruit will require further investigation.

(x) Proceedings of the Chemical Society, 1913, Vol. 29.

Milk of Palaquium Ellipticum, Benth.—Three samples of the latex were received and the coagulated biscuits of raw gutta prepared therefrom were analysed with the following results:—

—	No. 1.	No. 2.	No. 3.	Calculated on dry material.	
				No. 2.	No. 3.
Moisture	0·37	23·38	19·22	...	...
Proteids	1·90	0·27	0·24	0·35	0·30
Insolubles	4·13	5·27	4·50	6·86	5·57
Pure gutta	31·29	21·78	27·15	28·37	33·61
Resins	62·31	49·30	48·89	64·42	60·52
Ash	0·9	2·21	1·72	2·88	1·51

The first two of these samples were white and brittle and the last one was reddish in colour. From the above table it will be seen that all these samples of gutta are of inferior quality inasmuch as they contain more than 60 per cent. of resin.

Boswellia serrata gum resin.—The enquiry regarding the possible uses of this gum resin is still in progress. Its average composition is:—

	Per cent.
Oil	8
Resin	49·63
Gum	25·99
Moisture	11·91
Impurities	4·47
	100·00

A sample of turpentine oil obtained from the resin yielded the following results on fractional distillation:—

	Per cent.
Portion passing below 160° C.	50
" " between 160° C.—167° C.	17·5
" " " 167° C. and 180° C.	11·0
" " above 180° C.	21·5
	100·0

These figures indicate a turpentine oil of commercial value. Accordingly a small sample was sent to Messrs. Turner, Morrison & Co., Calcutta, who reported on it favourably as "promising." Preliminary experiments have shown that the distillation of gum resins of this type requires a still of special construction, since in the ordinary stills the gelatinous gum surrounds the particles of resin and thus prevents the full action of the steam. A special still is therefore now being constructed and is expected to be in working order next year.

The resin of this species was chemically examined with the following results:—

Specific gravity	1·8424 at 20° C.
Saponification number	77·33
Acid number	43·72
Ester number	33·61
Iodine	77·49

Tanning materials.—At the request of various Forest Officers several tanning materials were analysed during the year. A sample of *Terminalia paniculata* bark was found to contain 26·07 per cent. of tannin and 9·45 per cent. of non-tannin. It is thus a rich tanning material and might find a place in the tanning industry. A tannin extract is being prepared from it for further study. Twelve different samples of tan barks and fruits were received from Gwalior State for analysis, but most of these were found to be useless as tanning materials, either because they were too poor in tannin content or because the percentage of non-tannin in them was too high. The best of the samples was *Acacia leucophlœa.* It contained 11 per cent. of tannin and 4 per cent. of non-tannin. *Terminalia Arjuna* contained 12 per cent. of tannin and 8 per cent. of non-tannin and *Zizyphus xylopyrus* from Sipri, 14 per cent. of tannin and 9 per cent. of non-tannin. These are, therefore, tanning materials of average quality. An exceedingly rich tanning material, *Din-gun-the* pods, was received from Burma. It greatly resembles Divi-Divi both in appearance and in tannin value and contains 47·74 per cent. of tannin. The botanical name of this species has not yet been definitely settled.

Two short notes, one on oak bark and the other on the bark of *Terminalia tomentosa* as tanning materials for the manufacture of tannin extracts, have been sent to the *Indian Forester* for publication. It has been shown therein that there is little probability of oak bark being used for tannin extracts in the near future, seeing that an abundance of richer and cheaper tanning materials is available in this country. As regards *Terminalia tomentosa* bark, all attempts to utilize it as a source of tan extracts have hitherto failed, but the enquiry is still being kept open at the Research Institute.

Sal soils.—Last year forty different samples of *sál* forest soils were analysed for different Forest Officers. Of these 10 samples were received from the Forest Botanist, 24 from the Divisional Forest Officer, Mandla Division, and 6 from the Divisional Forest Officer, Jalpaiguri Division.

Sundri fruits.—These fruits were analysed with a view to discovering some economic use for its starch, either as a famine food or as a source of soluble starch, spirit, etc. The following is the average composition of the fruit:—

	Per cent.
Moisture	16·85
Tannin	4·44
Fat	4·50
Starch	59·53
Albuminoids	5·60
Woody fibre, etc.	6·38
Ash	2·70
Nitrogen	8·84

Nutrient value:—Albuminoids + starch + starch equivalent of oil (2·3 being the starch equivalent of oil) = 75·48.

Nutrient ratio:—Albuminoids : starch = 1 : 10·63.

It is clear that the fruit may be used as a famine food provided that the tannin is first removed by means of treatment with cold water. The enquiry as to its other possible economic uses is still in progress.

Ceara rubber.—The analysis of a thin sheet of Ceara rubber obtained from Coorg and sent by Mr. W. Raitt gave the following percentages:—

	Per cent.
Moisture	0·85
Proteids	4·10
Resins	11·24
Caoutchouc	82·91
Ash	0·90
Nitrogen	6·56

This sample was a very clean piece of well prepared rubber and it compares favourably with rubbers grown in Ceylon, East Africa and other places. On account of the high percentage of resin, however, its quality is inferior to that of first grade Ceylon rubber. It is hoped that this defect may be removed by more careful treatment.

Neem toddy.—A bottle of the spontaneous exudation of the Neem tree was received from the Conservator of Forests, Gwalior State, and it was analysed by Mr. T. P. Ghose, B.Sc. This toddy is popularly regarded as a remedy for leprosy. The object of the analysis was to

determine its average composition and to locate the active principle. The following is the result of the analysis:—

Specific gravity at 18° C.	1·0589
Angle of rotation at 15° C.	+ 11°
	Per cent.
Moisture	86·56
Proteids	0·36
Gums and colouring matter	6·17
Glucose	2·99
Sucrose	3·51
Ash	0·41

The qualitative analysis of the ash showed the presence of the following substances:—

Potassium, iron, aluminium, calcium, and carbon-dioxide.

Only a trace of resinous and fatty matter was obtained and tests for alkaloids and glucosides gave negative results. No active principle therefore could be located.

Nickel tannates.—These salts were studied to some extent last year. It has already been reported that under different conditions of precipitation tannates of different nickel contents are obtained. These conditions have been further studied this year and it is found that not more than two salts can be obtained by any change in these conditions. One is obtained when nickel hydroxide, dissolved either in ammonium chloride or ammonium acetate, is added to an excess of tannic acid solution, and the other when tannic acid solution is added to an excess of nickel hydroxide solution. These salts gave on incineration the following percentage of NiO:—

(*i*) The salt precipitated from excess of tannic acid 8·74 per cent.

(*ii*) The salt precipitated from excess of nickel hydroxide solution 28·34 per cent.

These salts were the same as reported last year and the question of their constitution has yet to be settled. The work will probably be taken up again next year.

Distillation of Khas Khas oil.—The distillation of Khas Khas grass with a view to determine the variation in oil-content of samples grown in different localities was taken up during the year. Five specimens were examined and in four of these the percentage of oil was found to vary from ·7 to 1; the other specimen was relatively poor and contained only 0·4 per cent. of oil. More specimens are being examined and the enquiry will, it is hoped, be completed next year.

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ASTRONOMY.

BY

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Solar physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikánal, the Director being Mr. J. Evershed and the Assistant Director Mr. T. Royds. The chief instruments are:—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is to take photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and so shall emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikánal spectroheliograph the collimating and camera lenses each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the

centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun, and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) An autocollimating spectroheliograph built in the observatory workshop. This is attached to the side of the Cambridge instrument and shares in the very perfect transverse movement of the latter. It is designed for photographing the sun's disk in the hydrogen line C. A large grating is used to obtain the highly dispersed spectrum which is necessary in photographing with this line.

(*c*) A high dispersion spectrograph mounted on piers in the spectroheliograph room. This is fitted with special arrangements for rotating the sun's image on the slit plate, and for accurate guiding during long exposures on sunspots or prominences. A special device has also been added for photographing simultaneously the spectrum of an electric arc on either side of a solar spectrum. A grating by Rowland with $3\frac{1}{4}$-inch ruling is usually employed.

(*d*) An 18-inch parabolic mirror (the property of the Director) is mounted in the spectroheliograph room immediately in front of the 12-inch photo-visual lens. It is used to form the solar image on the slit plate of the high dispersion spectrograph. The mounting is on rollers and the mirror can either be moved into position in front of the lens with its centre in the axis of the beam of light coming from the heliostat, or it can be pushed to one side so as not to obstruct the light incident on the lens during employment of the spectroheliograph and associated instruments.

(*e*) An 8-inch visual achromatic lens from the Maharajah Takhtasinji Observatory, Poona, temporarily mounted in the spectroheliograph room on a pier near the Foucault siderostat. It is used for forming a solar image on the spectrograph slit specially for sunspot work.

(*f*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a $3\frac{1}{3}$-inch concave grating of 10-foot focus mounted on

Rowland's plan. A 2-inch parabolic grating can be substituted for the concave grating, and a collimating lens may be employed with either grating to cure astigmatism.

(*g*) A 6-inch equatorial refractor with large grating spectroscope attached is used for the study of sunspot and prominence spectra and for recording the prominences by visual methods. The equatorial mounting and the spectroscope are from the Maharajah Takhtasinji Observatory, Poona.

(*h*) A 6-inch equatorial refractor by Lerebour and Secretan fitted with a photovisual object glass acquired from the Poona Observatory. The instrument is used for obtaining the daily series of large scale photographs of the sun, and for direct observations.

Routine work.—In addition to the daily records obtained by the two spectroheliographs, the routine work includes visual examination of sunspots and faculæ, sunspot spectra, and of bright lines or displaced lines in spots and prominences. The position angles and forms of the prominences are also recorded. A monthly article describing the solar activity is contributed to the "Monthly Weather Review" while for more technical purposes bulletins and memoirs of the Observatory are issued ; of the former 30 have appeared while of the latter the first has been published.

The distribution of prominences.—A remarkable peculiarity in the distribution of the prominences has been brought to light from a study of the Kodaikánal records. If the prominences recorded on the east limb are compared with those of the west a numerical preponderance of east over west is found for each year since these observations were begun in 1904. The averages for the past eight years show that for every 100 prominences observed on the west side of the sun's axis 111 were recorded on the east side and this ratio is nearly constant for each of the eight years. This applies to all classes of prominences, but if the special class which is associated with sunspots is treated separately a considerably greater excess of east over west is found. Prominences showing displacements of the spectrum lines indicating violent movement also show a much greater eastern excess than the average of all prominences.

These results appear to show that both prominences and sunspots are more active when near the east limb than when near the west. The numerical preponderance and the increased activity on the east side is very difficult to explain except on the improbable hypothesis that the earth itself affects the distribution and activity of the prominences, and tends to extinguish the smaller prominences during their transit across the sun's visible hemisphere.

The cause, whatever it may be, is evidently connected with that which produces an excess of spots east of the central meridian of the sun, and the above enquiry was suggested by the very remarkable results obtained by Mrs. Maunder in her exhaustive analysis of the Greenwich sunspot records.

Spectroscopic investigations.—The large grating spectrograph has been employed in obtaining comparison spectra of the sun's opposite limbs, and of the limbs compared with the centre of the disk. A special reflecting device was constructed and used for photographing two or three spectra from different regions on the sun simultaneously and side by side on the plate. A large number of measures of the displacements of the lines at the sun's limb have been made and in addition numerous determinations of the equatorial speed of rotation of the sun.

The rotation results show systematically smaller velocities than the values obtained in 1906 and 1908 at Mount Wilson Observatory, the differences amounting to from 3 to 7 per cent. They agree, however, within 1 or 2 per cent. with the values obtained in 1911 at Cambridge. It seems possible that this indicates a real change of rotation speed in the sun's absorbing atmosphere, which may vary with the sunspot period, but further research is necessary to determine whether systematic errors affect the measures of different observers. A new method of measuring the plates has been devised which it is hoped may help to clear up this uncertainty.

Comparison spectra have also been obtained of the electric arc and the sun for comparing the wave lengths of the iron and nickel lines in the arc and in the sun. In some of the plates the comparison is with the centre of the sun's disk and in others with the east and west limbs. From the latter independent determinations of the equatorial rotation speed have been obtained and these are in agreement with the determinations from spectra in which the east and west limbs are directly confronted.

The displacements observed when the arc is compared with the centre of the disk are found not to agree with the residual displacements observed when the limb is compared with the centre and the rotation displacement is eliminated ; and there seems to be no clear relation between the amount of displacement for the different lines, either limb *minus* centre or centre *minus* arc, and the displacements due to pressure. It is of great importance to determine whether these small displacements in the solar lines are really due to pressure in the reversing layer as has been assumed hitherto. The above results would seem to throw great doubt on the generally accepted theory.

METEOROLOGY.

BY

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Upper air investigations.—Sanction has been given by Government for a scheme providing three lakhs to be spent in ten years on enquiries into the conditions of the upper air, and Mr. Field has been relieved of his duties at Simla in order to take charge of the work. The head-quarters are to be at Agra, where an observatory is being built and it is proposed to send up instruments twice a week on balloons to as great a height as can be attained. There are to be four or five auxiliary stations where, as also from Agra, instruments will be sent up to lesser heights, say 2 or 3 miles, in order to give information as to the conditions affecting daily weather.

Mr. Field was unfortunately obliged to take leave in August and has not yet returned, so that the initiation of the scheme has been delayed. In the meantime Mr. Harwood, who is to act as his assistant, has been making observations with pilot balloons at Simla and Darjiling, and is working out their results in addition to some previously made.

General meteorology.—Owing to shortness of staff at Simla it has only been possible for a very small amount of research work to be done there. Some progress has, however, been made in the examination of seasonal relationships, and it has been shown that in the great majority of cases the storms that give northern India its precipitation in the cold weather have travelled from Europe, being of the same type as those which give Europe rain through the year.

Publications.—The customary Daily Weather Reports of Simla, Calcutta, Bombay and Madras, the monthly and annual supplements to the Simla Daily Weather Report, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets were issued during the year.

TERRESTRIAL MAGNETISM.

BY

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Magnetic observatories.—*Bombay (Alibag).*—The Bombay Observatory, formerly maintained by the Local Government at Colaba, was moved to Alibag in consequence of the introduction of electric trams into the city : it is now directly under the Government of India, the Director being Mr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern, a set of sight-reading instruments of Eschenhagen pattern, a Schulze earth-inductor, and ordinary magnetometers and dip-circles. There is also a large declinometer for eye observations, and the old Colaba horizontal force and vertical force magnetographs were in April 1912 transferred to Alibag for use as eye-reading instruments. There is thus a duplicate equipment both for absolute values and for variations.

The instruments have been in good order and under regular observation.

Dehra Dun, Kodaikánal, Barrackpore and Toungoo.—These observatories were started as base stations in connection with the Magnetic Survey of India, and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles, earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained throughout the year. Observations for personal error (*vide* report for 1910-11) are now made periodically at Kodaikánal where the Director, Solar Physics Observatory, has kindly given permission to use the observatory chronograph.

The mean values of the magnetic elements for 1912 at the observatories are as follows :—

Observatory.	North Lat. and East Long.	Declination.	Horizontal force.	Vertical force.	North dip.
			C. G. S.	C. G. S.	
Alibag . .	18° 38′ 72° 52′	E. 0° 51′ 11″	·36874	·16367	23° 54′·8
Dehra Dun .	30° 10′ 19″ 78° 3′ 19″	E. 2° 25′·9	·33218	·32244	44° 8′·9
Barrackpore .	22° 46′ 29″ 88° 21′ 39″	E. 0° 44′·0	·37369	·22316	30° 50′·7
Kodaikánal .	10° 13′ 50″ 77° 27′ 46″	W. 1° 5′·8	·37543	·02616	3° 59′·1
Toungoo . .	16° 55′ 45″ 97° 27′ 3″	E. 0° 13′·4	·38889	·16548	23° 3′·1

Magnetic Survey.—*Field Operations, 1912-13.*—During the field season, three detachments were employed on field work under the Officer in charge (Captain Thomas, R.E.) and two provincial officers.

The Officer in charge inspected Barrackpore and Toungoo base stations, observed at repeat stations and subsequently carried out a preliminary survey of Ceylon.

The provincial officers were partly employed on detail survey and revision of the work of season 1901-02 and partly on revisiting repeat stations.

Comparative observations were made at the four survey base stations and at Alibag to determine the differences from the survey standard.

During the season full sets of magnetic observations were made at the following :—

58 repeat stations.

19 old stations revised.

42 new stations in Ceylon.

3 new stations in India.

20 detail survey stations in the Central Provinces.

Under repeat stations are included observations at the old field stations which were marked by pillars in 1910-11 ; these number in all 50 which, with the original 23 repeat stations, give 73 repeat stations in all or about 1 to 19 stations of the fundamental survey.

One detachment remained at head-quarters and was employed on the reduction of the declination data of the survey which is nearing completion.

The computing section which remains permanently at head-quarters was engaged on its normal work of computation and tabulation of the base station results.

Work during recess 1913.—The reduction and tabulation of the observatory data for 1912 have been completed for five quiet days per month; the results for "all days" will also shortly be available.

The computation of the field work of 1912-13 is in hand and will be completed before the end of the recess.

The investigation of the instrumental differences in H. F. referred to in the two last reports is nearing completion.

List of Publications.

EVERSHED, J. .	. On the presence of radium and the elements of the inactive group in the chromosphere. (*Bulletin No. XXVII.*)
,, ,, .	. On the relative numbers of prominences observed on the eastern and western limbs. (*Bulletin No. XXVIII.*)
,, ,, .	. Summary of prominence observations for the first half of the year 1912. (*Bulletin No. XXIX.*)
,, ,, .	. Summary of prominence observations for the second half of the year 1912. (*Bulletin No. XXX.*)
,, ,, .	. Summary of prominence observations for the first half of the year 1913. (*Bulletin No. XXXI.*)
,, ,, .	. A new method of estimating changes in the general radiation of the Sun. Read at the International Solar Union at Bonn in August 1913.
,, ,, .	. Report on sunspot spectra (a summary of the visual and photographic work done at Kodaikánal during the years 1910, 1911, and 1912). Read at the International Solar Union at Bonn in August 1913.
EVERSHED, J., & ROYDS, T.	Some spectroscopic measures of solar rotation. (*Monthly Notices, Astronomical Society.*)
FIELD, J. H., & JACOB, S. M.	On the rapid calculation of times of moonrise and moonset. (*Memoirs, Vol. XXI, Part IV.*)
ROYDS, T. .	. Prominence periodicities. (*Bulletin No. XXXIII.*)
,, ,, .	. The distribution in latitude of dark H markings. (*Monthly Notices, Astronomical Society.*)
ROYDS, T., & S. SITARAMA AIYAR.	The determination of ancient dates from astronomical data. (*Astronomical Society of India.*)
WALKER, GILBERT T.	Data of heavy rainfall over short periods in India. (*Memoirs, Vol. XXI, Part III.*)
,, ,,	. The liability to drought in India as compared with that in other countries. (*Memoirs, Vol. XXI, Part V.*)
,, ,,	. Monthly and annual rainfall normals. (*Memoirs, Vol. XXII, Part I.*)
WALKER, GILBERT T., PART I, & HEM RAJ, RAI BAHADUR, PART II.	The cold weather storms of Northern India. (*Memoirs, Vol. XXI, Part VII.*)

GEOLOGY.

BY

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CONTENTS.

MINERALOGY AND PETROLOGY.

1. **White pyroxene rock: tremolite: bowenite.**—Mr. Middlemiss has described some interesting mineral occurrences from the Aravallis of Idar State. At Bamanvada (lat. 23° 36′; long. 73° 20′) massive, white pyroxene rock is found associated with crystalline limestone and quartz-pyroxene schist, the whole series being intercalated as a band, 50 to 60 feet thick among mica schists. The coarsely crystalline, often pure white, pyroxene is found in beds of from a few feet to as much as 30 feet thick at one place, and may be traced at intervals for many miles. Although pyroxene as a constituent of many igneous rocks is common, this is the first instance recorded of extensive beds of the pure mineral having been found in India. Its optical and chemical characteristics are those of the diopside group of monoclinic pyroxenes, and it suffers local changes into white or pale green tremolite or actinolite in radiating tufts and interlaced fibres. Some of the latter layers are rather compact and semi-translucent, but not sufficiently so to have any value as jade (nephrite) as at present explored, though the occur-

rence is suggestive. The white pyroxene rock mottled here and there by the pale green tremolite makes a tough and handsome ornamental stone when polished.

2. At Bhetali, seven miles along the outcrop from Bamanvada, a grey mottled variety appears with graphite in nests and films round and among the pyroxene crystals. Some of the associated crystalline limestone at Bamanvada shows small patches of hard dark green serpentine (bowenite) resembling in a small way that from the Safed Koh described by McMahon (*Min. Mag.*, Vol. IX, p. 187, 1890). Mr. Middlemiss concludes from the lie and associations of this band of rocks that they are mainly the result of contract-metamorphism induced by dykes of olivine-gabbro and dolerite which penetrate the series.

3. **Idocrase.**—Mr. Middlemiss has further recorded massive idocrase (vesuvianite) from near Nadri (lat. 24° 0′; long. 73° 2′). This mineral does not seem to have been much more than mentioned before in India, with the exception of that from Tonk referred to by Mallet (*Man. Geol. of India*, pt. 4, *Mineralogy*, p. 93). Mr. Vredenburg doubtfully recognised it in some Idar granite collected by Professor Page, a point which so far Mr. Middlemiss has not been able to verify. The present occurrence is in metamorphic Aravalli limestones, which in the neighbourhood are modified by intrusive veins of granite and aplite into a rock composed of calcite, quartz, microcline, diopside, wollastonite, etc., and secondly into the rock now described, by further intrusion into them of the latter bosses of Idar granite. The rock is coarsely crystalline, with large shining cleavage plates of poikilitically developed idocrase among and including the other normal constituents of the calc-gneiss. The bands are several inches across, the proportion of the mineral to the rest of the rock being about 5 to 1. The determination is based on physical and optical tests, no chemical examination having yet been made.

4. **Teng-yueh volcanics.**—Mr. R. C. Burton has examined and described a series of volcanic rocks collected by Mr. Coggin Brown in the neighbourhood of Teng-yueh. These consist of three groups:—

(*a*) pyroxene-andesites;

(*b*) hornblende-andesites, pyroxene-andesites, with augite-olivine andesites and olivine basalt;

(*c*) olivine basalts.

These sub-divisions correspond with the three groups respectively termed by Mr. Brown "bedded andesites," "massive andesites" and "basalt lavas of Tay-in-shan," and are enumerated in order or age, the first being the oldest. The rocks of group (*a*) are very much older than those of group (*b*), which are of pliocene and pleistocene age, some

of the lavas, as for example those of the now extinct She-toe-shan crater, being of recent age.

5. In general characteristics the andesites and basalts described by Mr. Burton are similar to those of the younger Burmese volcanoes, the lava of Ho-shuen-shan being comparable to the late Tertiary basalts of the Northern Shan States. A specimen of augite andesite from Kan-lan-ssu contains a considerable amount of brown glass resembling the palagonite of the Rajmahal trap.

6. **A suggested infra-plutonic zone in the earth.**—An interesting paper read by Dr. Fermor before the Asiatic Society of Bengal (*Journ. A. S. B.*, Vol. VIII, No. 9, p. 315) led him to the consideration of the conditions existing below the surface of the earth, from which he has deduced the presence, below the plutonic zone, of a belt of material under high pressure and containing garnet as a typical constituent; this he terms the infra-plutonic zone (*Rec., Geol. Surv. India*, Vol. XLIII, p. 41). Although admittedly of a somewhat speculative nature, the views put forward by Dr. Fermor are of great interest and highly suggestive; his memoir on the subject when published will undoubtedly form a very important contribution to the study of the chemical and physical constitution of the earth.

PALÆONTOLOGY.

7. **Tertiary mammals in the British Museum.**—During his absence on study leave Dr. Pilgrim examined most of the types of mammalia now in the British Museum from the Upper Siwaliks of the Siwalik Hills, as also from Perim Island and Burma. These have been described partly by Falconer and partly by Lydekker, and there are very few duplicates in the Geological Museum in Calcuttta. Dr. Pilgrim also examined the fine collection of Pikermi species in the British Museum for purposes of comparison with our Middle Siwalik fauna. At the same time he worked out and described a small collection of *Carnivora* from the Lower Siwaliks of Chinji and also from the Middle Siwaliks. This work will, it is hoped, serve as a nucleus for a more extensive revision of the Siwalik *Carnivora* to be undertaken subsequently. Another group examined by Dr. Pilgrim was the *Mastodontidæ*, which he found to be also in need of revision.

8. Mr. Swinhoe's collection of mammals, which is in the British Museum, was also examined. The specimens are from two localities, namely, (1) the right bank of the Irrawadi opposite Mandalay and (2) near Yenangyaung. The collection from the former locality was found to include *Elephas antiquus* (*namadicus*) and is therefore presumably of pleistocene age. Among the specimens from near Yenangyaung Dr. Pilgrim found a new species of *Merycopotamus*, of which, with

Dr. Smith Woodward's consent, he has written a description. Other interesting specimens noticed were a skull from Perim Island attributed by Lydekker to the genus *Strepsiceros*. Dr. Pilgrim on developing this specimen to a considerably greater extent than had formerly been done, found the generic attribution no longer tenable and regards the skull as representing a new genus.

9. Another interesting skull which had apparently been overlooked for some years bears a label containing the word "Ava." If the specimen really came from Ava its age is presumably Middle Siwalik, since numerous Middle Siwalik species have been obtained from that locality. If this is so, its presence is interesting, since Dr. Pilgrim regards it as undoubtedly an ancestral form of the Pliocene *Leptobos*. He also found that it possessed decided antelopine affinities. In view of the interest attaching to it Dr. Pilgrim wrote a description of the specimen with Dr. Smith Woodward's permission.

10. A fine collection of *Hipparion* skulls from Pikermi also proved of considerable interest, being found to comprise two species, namely, the pontian form *H. gracile* and also another which Dr. Pilgrim regards as almost, if not quite, identical with the Indian form *H. punjabiense*, from the Middle Siwaliks of the Salt Range.

11. **Tertiary mammals at Basle.**—Dr. Pilgrim also paid a visit to Basle where Professor Stehlin very kindly allowed him to examine numerous specimens which proved to be interesting and useful for purposes of comparison with Siwalik forms.

12. **Tertiary Mollusca of Sind and Baluchistan.**—Mr. Vredenburg was also absent on study leave during the year and examined collections of Tertiary invertebrate fossils both in England and on the Continent, for purposes of comparison with the Tertiary fossils of Sind and Baluchistan, on a description of which he has been engaged for some years past. His work comprises two main sections, firstly, the revision of the Sind Tertiary types of D'Archiac and Haime, and secondly, a complete description of the post-eocene Tertiary molluscan fauna of North-Western India. D'Archiac and Haime's types have been carefully revised and their geological horizons ascertained. Most of the mollusca proved to be from the Gaj and Lakhi stages, the Gaj being chiefly represented and the fossils from it as a rule well preserved, whereas the specimens from the Lakhi stage were usually casts. There are also a few Ranikot forms, very few from the Nari, none from the Khirthar, and only one from the Cretaceous. The post-eocene mollusca that have been described by Mr. Vredenburg comprise over 350 species of which about 120 are new. Mr. Vredenburg finds that the only forms that show any close relationship to European species are those from the Nari, whereas the percentage becomes very small in the Gaj beds and

still smaller, practically none, in the Hinglaj, the fossils of which latter stage are closely related to those of Java.

13. **Jurassic ammonites.**—Before taking leave Mr. Tipper was engaged on the description of the Jurassic fossils from Baluchistan on which he has been engaged for some years. He has made considerable progress in the work and it is hoped that his results will soon be ready for publication.

14. **Palæontological work being done in Europe.**—The Cretaceous fossils collected by me at Kampa dzong and Tuna in Tibet and the Jurassic brachiopods collected by Messrs. La Touche and Datta in the Shan States are still in the hands of Professor Douvillé and Mr. S. S. Buckman respectively.

15. Collections of Palæozoic fossils made by Mr. Griesbach in N. W. Afghanistan and Khorasan and by me in the Koh-i-Baba have been examined and described by Miss Colley March, B.Sc., of Manchester University. Mr. Griesbach's collections contain well-preserved brachiopods, the best having been obtained from Robat-i-pai near Herat; they include species of *Spirifer* (cf. *bisulcatus* and cf. *clathratus*), *Productus* (*semireticulatus* and *pustulosus*), *Camarophoria* cf. *purdoni* and *Atrypa aspera*. Miss March regards these fossils as essentially Lower Carboniferous, and ascribes the presence of *Atrypa aspera* to a local survival of this species beyond the usual Devonian limit; experience of the difficulties under which specimens are collected during expeditions of the kind on which Mr. Griesbach was engaged at the time, would dispose me rather to infer that he had not had an opportunity of working out horizons in detail and consequently did not suspect the presence of more than one system; it is clear from his lists that fossils collected from beds some little vertical distance apart were not differentiated, and the collection might thus easily contain both Lower Carboniferous and Upper Devonian species. The close association of fossils belonging to these two systems near the Kotal-i-Hajigak in the Koh-i-Baba lends considerable colour to this explanation.

16. Miss March has also described the fossils collected by me from the upper beds of the Hajigak limestone; they are badly preserved, but were found to include *Spirifer wynnei*, *Chonetes* cf. *hardrensis*, (?) *Phillipsia derbiensis*, a new species of *Streblodus* named by Miss March *Str. incurvus*, and several species of *Zaphrentis* and *Syringopora*. The most striking feature of all these fossils is, according to Miss March, their close affinity to European forms. Their age is regarded as Lower Carboniferous.

17. A description of the lamellibranchs of the Ranikot stage by Messrs. Cossmann and Pissarro has been received and will shortly be published.

18. During the year, Professor Seward completed his examination and description of the Gondwana plants collected by Mr. Middlemiss on the Golabgarh pass. These include *Glossopteris indica* Schimp and *Cordaites hislopi* Bunb., both typical species of the Lower Gondwanas of the peninsula; they thus furnish unequivocal evidence of the identity of the Gondwanas of Kashmir with those of the coal-fields of India. Professor Seward's memoir has been published in the *Palæontologia Indica*.

ECONOMIC ENQUIRIES.

Building Stones.

19. The limestone of which the Simla town-hall is built was submitted to the Geological Survey for examination and report. It was said to have been obtained from the quarries on Prospect Hill and was found to be very friable and impure, and not suitable for building purposes. Specimens of the Sanjauli quartzite were also examined and found to be excellent building-stones.

Coal.

20. **Raniganj coal-field.**—The re-survey of the Raniganj coal-field and revision of the map originally prepared by the late Dr. Blandford, on which Mr. Walker was engaged on behalf of the Mining and Geological Institute, in co-operation with a committee of the members of that body, was completed during the year. Mr. Walker's report on the correlation of the seams has also been handed over to the Institute by which it will be published.

21. **Coal in Korea State, Central Provinces.**—Attention having recently been drawn to the possibility of exploiting profitably the coal-fields in the Korea State of the Central Provinces originally examined by Mr. Hughes (*Memoirs, Geol. Surv. India,* XXI, pt. 3), the Chief Commissioner has asked that a member of the Geological Survey should make a more detailed examination of the area. The matter has therefore been taken up by the Central Provinces party and Dr. L. L. Fermor proceeded to Korea at the end of the year. Having only just arrived on the field at the conclusion of the period covered by this report, his results are not yet available. Samples of coal, however, were sent for assay to this Department in September 1912, by the Political Agent, Chhatisgarh Feudatory States; these proved to be of fair quality, the percentage of ash being about 6; the percentage of moisture is undesirably high and varies from 7 to 10 per cent.; the calorific value of the better samples ranged between 6,650 and 6,850. The localities from which the best samples were obtained are Kouraia nala, Kurasia and Kukri nala.

Engineering Questions.

22. **Darjiling landslips.**—In pursuance of the recommendations of the Landslip Committee which met in Darjiling in October 1911, Dr. L. L. Fermor was employed during the summer of 1912 in making a detailed geological survey of the Happy Valley and neighbouring hill-sides. Through the courtesy of Lt.-Colonel R. T. Crichton, C.I.E., Director of Surveys, Bengal, he was provided with large contoured maps. Dr. Fermor's more extensive survey has, while greatly amplifying them, tended to confirm the results arrived at by the committee. His recommendations and conclusions have been forwarded to the Government of Bengal.

23. **Dharmsala hill slopes.**—The conditions of the hill slopes at Dharmsala having given cause for apprehension lest landslips might occur, a committee was appointed to examine the station and report to the Local Government. The services of a member of the Geological Survey having been asked for in this connection, Mr. C. S. Middlemiss joined the committee on his way back from field-work in Kashmir at the end of the monsoon season. Having visited Dharmsala in 1905 in the course of his investigation of the effects of the great earthquake of April 4th, his intimate knowledge of the geological conditions rendered Mr. Middlemiss peculiarly suitable for this further investigation. His conclusions, which were submitted with the report of the committee, tend to show that there is no immediate danger to be apprehended so long as certain necessary precautions be taken without delay. These include the afforestation of bare hill-sides and the closing to grazing and wood-cutting of those already partially deforested; in addition to this certain measures are recommended with regard to rendering the water channels and the drainage system more efficient.

Gold.

24. **Burma.**—Mr. H. S. Bion was deputed at the beginning of the field-season of 1912-13 to take up the examination of the auriferous gravels of the Chindwin river. His work only covers a short period during the year under review, and comprised chiefly an inspection of the gravels at the small gold-washing villages of Manlaikgyi and Manlaikgale, seven miles below Kindat; these were found to be valueless. The gravel island opposite Helaw was also examined and the gold content found to be very irregularly distributed. The surface gravels, which are quite rich in places (carrying from 8 to 15 grains per cubic yard), are barren in others. Only the surface is rich, there being practically no gold at a depth of four feet. Traces of platinum also were met with.

Iron.

25. **Goa and Ratnagiri.**—In March 1912, Dr. Fermor visited the iron-ore deposits of Goa and Ratnagiri, where the Compagnie des Mines de Fer de Goa and Messrs. Jambon & Co. respectively gave him every facility to inspect their properties. In Goa, the iron-ore occurs in beds of the Dharwar system, and the total amount is believed to be very considerable. In the southern parts of Ratnagiri and in the adjoining State of Savantvadi, similar geological conditions prevail, and deposits of iron-ore have been found, at Redi in Ratnagiri and near Banda in Savantvadi. It is considered probable that before long an export trade may be developed from this part of India.

26. **Jaipur State.**—Mr. Heron records the presence of large quantities of hematite in the Raialo marbles near Raialo and Nimla. He attributes these deposits to metasomatic replacement of the calcite by iron-bearing solutions. Whenever a hillock is seen in the Raialo marble, it is found to be due to the superior resistance to denudation of these masses, which stand out as dark-coloured piles of rock from the level stony plain of yellow or pale brown weathered marble. The rock varies, according to the amount of replacement, from marble stained brown by iron, to nearly pure hematite. The deposits are elongated more or less in the direction of the strike, but thicken and thin out in a quite irregular fashion; they are, in fact, lines of irregular lenticular masses rather than bands. It is difficult to estimate their real thickness, as the slopes are covered with boulders which are strewn to a great distance around and quite obscure the rocks beneath, giving an appearance of thickness greater than is really the case. Bands up to seven or eight feet across of pure hematite, were measured, and there are many much wider. If thin calcareous bands, which would be mined along with the ore and eliminated by hand-picking, are included, the width must run to many yards, and the amount of ore is certainly very great. The locality is situated about 15 miles from Dosa railway station, the intervening country presenting no impediment to railway and tramway construction. Extensive old workings are also seen near Nimla and between Raialo and Kalajpuri; these probably supplied part of the raw material for the now extinct iron industry of Bhangarh.

Kaolin.

27. **Jaipur State.**—Mr. Heron records the presence in Jaipur State of deposits of kaolin which may possibly be of value. $1\frac{1}{4}$ mile S. E. of Rasnu (26° 41′; 76° 37′) a long and spacious tunnel has been driven along the strike of a bed of kaolin which runs midway in the ridge of Alwar quartzites and is about 20 yards wide, white but rather impure, banded with quartzite. There is evidently a very large quantity available.

It has been quarried for local uses only, such as white-washing, etc. Kaolin is also dug from the soft argillaceous and talcose zone near the base of the Alwars at the north end of the Lalso hills, chiefly near Daraoli (26° 55′; 76° 58′). There are two beds separated by quartzite; the upper one provides a white and fairly pure clay, slightly mottled with pale purple and pink.

Petroleum.

28. **Assam.**—Mr. Pascoe completed his examination of the petroliferous localities of Assam and prepared a memoir which is now in process of publication.

29. **Burma.**—During the early part of the year, Mr. Cotter was on duty at the Yenangyaung oilfield, where he was succeeded by Mr. Coggin Brown. Owing, however, to his health giving way, the latter officer was relieved in July by Mr. Heron, who remained at Yenangyaung until the beginning of the field-season of 1912-13.

30. Sub-Assistant Sethu Rama Rau describes petroliferous areas at Yeyodaung and 3 miles N. N. W. of Nga-hlain-dwin in Minbu district. At the former locality, where a Burmese well has been dug, the beds at the crest of the anticline dip at low angles of from 10° to 12°. There are also a few Burmese wells at the second locality, and both places are regarded as being probably of economic value. The oil is said to occur in the upper beds of the eocene series.

31. **Punjab and North-West Frontier Province.**—Having completed his work in Assam, Mr. Pascoe proceeded to examine the petroliferous localities of the Punjab and North-West Frontier Province, and was still engaged on this work when an attack of suspected enteric compelled him to return to hospital at Lahore. His results are not therefore available yet.

Potash Salts.

32. **Salt Range.**—Dr. W. A. K. Christie was deputed in January to the Salt Range in the Jhelum District of the Punjab to investigate the potash salts found in his previous prospecting operations in the rock-salt mines at Khewra and Nurpur, worked by the Department of Northern India Salt Revenue. The potash beds found in the Mayo Mine at Khewra are generally overlain by seams of unsaleable marl, and their investigation is rendered difficult because the mining authorities, being mainly concerned with the extraction of marketable salt, which exists in unlimited quantities, naturally change the sphere of their operations as soon as a marl seam is struck and before the deposit underlying it is exposed. The principal potash-bearing bed found in the Pharwala section of the Mayo Mine was traced at various points for some 850 feet

along its strike, and over 250 feet with the dip, which is about N. 30° W., with an inclination of 20 to 50°. Its average thickness is six feet and the potash content varies from 6·8 to 9·6 per cent of K_2O. The distances given are indications of the comparatively extensive nature of the deposit, but they are not intended as a basis for calculation of the material available for extraction, as questions of expediency in pillar preservation completed the issue. Another seam eight feet thick and carrying 7·7 per cent of K_2O was found in a prospecting drift in the Pharwala salt,—what was presumably the same bed being struck in another prospecting drift 700 feet to the E. N. E. In the Buggy section of the Mayo Mine the only seam of any importance that was found was traced for about 150 feet along its strike, which is E. N. E.—W. S. W. The dip of the bed is about 35°, its average thickness two feet nine inches, and it carries 14·4 per cent of K_2O. The seam thins out when followed upwards along the bedding; in another chamber, at a distance of 170 feet south from the nearest exposure, it was found to be only a few inches thick. The seam in the Nurpur mine is exposed only in one place which is difficult of access. It dips S. S. E. at about 75° and at this point is six feet thick. A typical specimen from this deposit carried 14·1 per cent of K_2O.

33. The potassium-bearing minerals of the salt formation are chiefly langbeinite and sylvin, kainite and blödite with a small percentage of potassium being often present in small quantities. The deposits are usually fine-grained mixtures of these minerals with common salt and kieserite. The economic bearing of the occurrences, together with questions of their mineralogy and genesis, will be discussed in a paper now under preparation.

Steatite.

34. **Jaipur State.**—In addition to the locality of Morra long known for its steatite, Mr. Heron describes other and hitherto unrecorded localities where that mineral is extensively developed in thick beds of great purity. The new localities are Dogetha (Dagota), 2¼ miles N. E. of Raialo (lat. 27° 5′; long. 76° 15′), Gisgarh (lat. 26° 53′; long. 76° 40′), and Kawa (lat. 26° 46′; long. 76° 32′). The Dogetha deposit is excavated to a width of about 30 yards, but is probably wider, as the country rock on either side is not laid bare. It runs diagonally, dipping at 80° west by south, across the end of a hill and is only excavated for some 50 or 60 yards along the length of the bed in an open cutting. The steatite is very pure, milk-white or faintly tinged with green, with very thin films of pink ferruginous matter in some of the joints. The joints are irregular and allow of pieces up to one foot or so in length being extracted, but most of the material is in much smaller pieces and

no particular effort is made to get large blocks. The deposit is quite structureless except for the jointing, and no clue could be obtained as to its origin; in no place was a junction with the surrounding rock seen. The cost of excavation is about one rupee for six or seven maunds. It is transported to Dosa station on pack bullocks at two annas per maund. Rs. 3,000 is said to be the annual rent paid for the quarry. From Dosa it is sent mainly to Amritsar and some to Cawnpore.

At Gisgarh the bed is only 2 feet thick and the material inferior to that of Dogetha. At Kawa only traces of steatite were noticed in a well.

With regard to Morra-bhandari, the original locality described by Hacket as the source of the stone used by the Agra stonecarvers, Mr. Heron describes the deposit as extending for 5 miles in the form of richer pockets in a stratum concentrated from talcose schist. One of these is mentioned as being about 25 feet thick. Work is only being done at one place 1 mile west of Morra (lat. 26° 49′; long. 76° 51′).

Water.

35. **Itarsi.**—At the request of the Railway Board, Mr. H. C. Jones visited Itarsi in June, on behalf of the Great Indian Peninsula Railway, in order to report on a proposed scheme for a reservoir. The site chosen for the dam proved unsuitable owing to the porosity of all the rocks in the neighbourhood and no suitable site could be obtained.

36. **Rajdaha, Manbhum district.**—In December I paid a short visit to Rajdaha near Topchanchi in Manbhum district, to examine a site for a dam in connection with an important project for a water-supply for the Jherriah coal-field. It is proposed to build a dam across a small valley immediately below the village of Rajdaha and thus to impound a large body of water. The site for the dam had been chosen where a belt of hornblende-gneiss crosses the valley; this appeared to offer a suitable foundation.

Wolfram.

37. **Tavoy.**—Mr. Page continued his investigations into the condition of the wolfram industry in Mergui and Tavoy. The absence of reliable maps has led to serious difficulties in the matter of granting licenses and leases and Mr. Page's work has been largely of a clerical nature with a view to preventing the confusion that inevitably follows the failure on the part of applicants to define exactly the boundaries of the concessions for which they apply. Mr. Page is preparing an *ad interim* report and it is hoped that by the end of the present field-season he will be in a position to make final recommendations.

GEOLOGICAL SURVEYS.

Bombay, Central India and Rajputana.

38. **Mr. C. S. Middlemiss: Idar State.**—Mr. Middlemiss continued his survey in Idar State, begun the previous season, and completed all the main portion of that State, so far as areas of solid geology are concerned, with the exception of a few strips and corners along the north and east boundaries which will be finished off later in conjunction with other outlying parts of Mahi Kantha Agency. The area is included in the following sheets of the 1″ = 1 mile Bombay Survey (the numbers in brackets refer to the same sheets numbered according to the Central India and Rajputana Survey):—Nos. 119, 143 (120), 144 (121), 145 (122), 146 (123) and 179 (150).

39. The mapping of the calc-gneisses of the Aravalli system, mentioned in the preceding annual report, was continued north of last year's area into the long strip of Idar territory lying between Udepur on the east and Danta on the west. There, in the neighbourhood of Kherod (lat. 24° 14′; long. 73° 3′) an important modification takes place. Instead of being composed as in the Vadali neighbourhood of calcite, quartz, microcline, diopside, wollastonite, scapolite, etc., profusely penetrated by aplite and pegmatite veins, it takes the form of a dark rock composed mainly of crystalline calcite penetrated on a very minute scale by *lit-par-lit* layers of basic hornblende-felspar material (amphibolite), the resulting complex being a precise reproduction in some of its varieties of the amphibolites described by Adams and Barlow in Canada.* This series, which may be called the Kherod amphibolite series, is folded along with garnetiferous mica-schists and phyllites, and seems to underlie to the west the ordinary calc-gneisses of the Vadali area. The full examination of these rocks is still incomplete in the direction of Posina.

40. Other modifications of the calc-gneiss series, with the production of massive idocrase at one locality, and thick beds of white pyroxene and other rocks at another, are referred to in more detail in a separate part of this report (*supra*, paras. 1—3); whilst the steatite, absestos and associated serpentine, magnesite, etc., of Kundol have already been noticed in the preceding annual report and in a short article by Mr. Middlemiss published in the *Records of the Geological Survey of India*, (Vol. XLII, p. 52).

41. Several instructive examples, demonstrating the later intrusion of the Idar granite masses across the sharply truncated edges of the Aravallis with their included older granite veins, were specially noted this

* Geol. of Haliburton and Bancroft areas, Ontario, Dept. of Mines, Geol. Surv. Branch, Mem. No. 6 (1910), pp. 157—172.

season, one being at the N. W. edge of the Dharol hill (lat. 24° 0′; long. 73° 2′) and another at Asai hill (lat. 23° 55′; long. 73° 3′). A few new types were noted among the older aplites and granite veins, one of which is a medium-grained granite with allanite in crystalline grains completely taking the place of the usual ferromagnesian constituents.

42. The exact lie of the Aravalli complex with reference to the succeeding Delhi quartzite is generally not very clear in Idar State, but at one locality near Khercha (lat. 23° 40′; long. 73° 24′) observed last season, the wandering strike directions of the former show complete discordance against and beneath the presumably younger massive Delhi quartzite. The latter itself, whilst building all the rather lofty and sturdy hill ranges, of this part of the country, is also most intricately involved in foldings, twistings and crushings, whose complexity is such as to render any exact reproduction of them in section very difficult; the outcrop and strike are generally self-evident, but evidence of dip in these rocks is not often reliable.

43. The Delhi quartzite again in turn appears to be succeeded on its eastern border by an extensive younger series of soft, thin-bedded and splintery schists or phyllites, of pale drab, yellowish and greenish colours, quite distinct from the Aravallis, and unlike them pierced by no plutonic intrusives, but only by numerous white quartz veins. These build a third type of country, distinct, on the one hand, from that of the alluvium-covered Aravallis, and on the other, from the massive ridges of Delhi quartzite. It consists of long, low, undulating hills with ribs of vein quartz, the whole making a confused, labyrinthine tract of low knolls and intricate stream-beds, the favourite haunt of the Bhils. In its further extension to the east, this series of phyllites merges into those of Dungarpur State east of Isri and Meghraj, where their survey is still awaiting completion.

44. **Mr. H. C. Jones: Gwalior and Tonk.**—Mr. Jones, continuing his survey of last year in Gwalior, proceeded to the southern part of the main area of that State which lies north-east of Bhilsa town (lat. 23° 31′; long. 77° 52′), and is contained in the 1″=1 mile standard sheets, Nos. 374, 375, 376, 392, 393, and 394 of the Central India and Rajputana Topographical Survey. Only towards the end of the season, in March, was he able to continue his survey still further north into a portion of Tonk State adjoining the Bhilsa district. The area surveyed, on its south-west border, marches with that already mapped in detail, partly by E. Vredenburg (season 1897-98) and partly by C. S. Middlemiss, H. Walker and Sethu Rama Rau (season 1904-05). The great diversity of Upper Vindhyan rock stages, from Lower Kaimur sandstone to Upper Bhander, so well exposed in that completed area, was not found, however, to continue into the ground surveyed by Mr. Jones, and

which is now under review. The latter proved to be mainly Deccan Trap and alluvium, with here and there groups of isolated tabular hills composed solely of one or two members of the Upper Vindhyan sequence, namely, false-bedded, purple and mottled sandstone, judged to be of Lower Bhander horizon, underlain locally, as at Udepur (lat. 23° 54′; long. 78° 5′) by greenish and purple shales presumed to be the Ganurgarh shales, and at one place, namely, three miles south-west of Hydergarh Basoda (lat. 23° 37′; long. 28° 14′), by a limited exposure of siliceous limestones. On account of the entirely detached, inlying character of the exposures, surrounded as they are on all sides by wide expanses of Deccan Trap and alluvial valleys, Mr. Jones cannot be absolutely certain of the exact horizons of these rocks (some of which may possibly belong to the Rewa stage).

45. The country, which is a moderately level plain, lies at a general elevation of about 1,800 feet, diversified by isolated hills and hill ranges rising another 400 feet above that. These latter are mostly the sandstone as described above, generally horizontal, but dipping 2° or 3° north-west in the south-west part of the area, and dipping east near Udepur (23° 54′; 78° 5′). The Deccan Trap presents no new features and consists of superposed sheets of dark, fine-grained basalt without olivine and with amygdaloidal layers and interrupted rarely by a very thin and often disrupted bed of Intertrappean limestone and chart, which sometimes becomes a mere collection of residual blocks. No fossils were yielded by these Intertrappeans.

46. Ferruginous laterite and residual laterite lie in frequent but discontinuous patches, especially in the north-west parts of the area. Some fragments of an aluminous variety were noted near Hura (Saugor district). Good cotton soil covers most of the flatter parts, especially those in the north of Bhilsa district.

47. **Economic.**—Nothing of special economic importance is reported. Excellent building and flag stones are of course obtained from the Vindhyans. Ferruginous laterite, once a source of iron, is now largely used as road metal.

48. **Mr. A. M. Heron: Jaipur State.**—Mr. Heron, having in previous years surveyed in detail Alwar State and the neighbouring geologically connected areas to the east, turned his attention during the last working season to the part of Jaipur State lying to the south and south-west of his original base of operations in Alwar. The area surveyed, besides a large portion of Jaipur, includes also the Tonk Pargana of Tonk State, the Chiefship of Lawa and certain detached villages of Bundi State (the Bundi and Lawa areas being completely enclosed by Jaipur territory). This large area is comprised within eighteen standard (1″ = 1 mile) sheets of the Central India and Rajputana

Survey, namely, Nos. 229 to 232, 260 to 265, 288 to 292 and 316 to 318. Of these sheets Nos. 261 to 263, 289 to 292 and 316 to 317 have been completely surveyed geologically, and 264, 265 and 318 finished so far as Jaipur State is concerned.

49. The area, like that previously revised by Mr. Heron, had already over thirty years ago been surveyed by Hacket, and the geology and economic resources outlined in several publications by that author.* Its re-survey was necessary, in continuation of the regular revision of Hacket's work in this area, for reasons explained in previous General Reports. Excluding sheets 288 and 316, mapped in previous years, the rest of the area stretching to the south and south-west is a vast alluvial and sandy plain with only very occasional, narrow, strike-ridges (*mala*) and stripes and patches of rock with north-east—south-west alignments, rising out of that plain. Of these the Lalsot-Toda Bhim elongated ridge-mass stretches for over 40 miles in length, and has been mapped by Mr. Heron as "Delhi system," but described in his report as the Alwar series. Others again, stretching for even longer distances, and sometimes extremely attenuated, expose only the metamorphic Aravallis, with small areas of intrusive granite, pegmatite and quartz veins. In this newly surveyed region, outside sheet 288, none of the lower members of the Delhi system, namely, the Raialo quartzite and limestone, which come normally below the Alwars, have been recognised. Similarly, none of the series above the Alwar quartzite, namely, the Ajabgarh series and Hornstone Breccia, have been certainly detected. Thus the Delhi system is here restricted so far as outcrops are concerned to its middle member, namely, the Alwar or Delhi quartzite series; but it is possible that the other lower and upper members may lie hidden beneath the alluvium.

50. Having revisited the old area of the Raialos, Mr. Heron finally rejects the tentatively expressed idea that the granite is intrusive into them, and now believes them to lie unconformably upon it. It seems now established, therefore, that the Delhi system lies unconformably above the Aravallis and above their intrusive massive granites, though certain pegmatite veins cut through all the systems including, though rarely, the Ajabgarhs.

51. Mr. Heron's report enters very clearly and fully into the description of the new areas. The metamorphic origin of the Aravallis is amply demonstrated by the varying amounts of alteration of them from hardened, though uncleaved, shales to coarsely crystalline biotite schists with staurolite or garnet in great quantity. The dark, impure, thin-bedded quartzites associated with them are deemed to be quite different from the Alwar quartzites (though sometimes marked as such by Hacket) and never like the latter showing ripple-marks. Strictly subordinate

*Rec. Geol. Surv India, Vol. X, pt. 2 (1887), Vol. XIII, pt. 4 (1880), and Vol. XIV, pt. 4 (1881).

to the above are schistose conglomerates, grits and impure argillaceous limestones and epidiorites, of uncertain origin. The general dip is north-west at high angles of from 30° to vertical. The rocks intrusive in these are quartz veins with a small amount of tourmaline, bosses of granite, slightly pressure-foliated, medium-grained and porphyritic, with a groundmass of microcline and a micrographic intergrowth of quartz and felspar; aplite veins; and pegmatites in masses of all sizes from half an inch to many yards across and of medium to extremely coarse grain, their mineral constitution only differing from that of the granites by the presence of tourmaline. The Alwar quartzite representatives of the Delhi system are caught up among the Aravallis in a double or triple set of synclinal folds combined with anticlines by rapid variation in the pitch of the axes, and some of them resemble more nearly those of the Biana Hills (described last year) than those of Alwar.

52. Only one doubtful occurrence of a black brecciated slate near Podampura (lat. 26° 51′; long. 76° 49′) may represent the Ajabgarh series. The rest of the country is a vast expanse of light loam and sand hills, the latter heaped up by the prevailing winds on the western faces of the rocky ridges, but not much resembling the travelling dunes of more desert-like areas, inasmuch as they all bear a scanty vegetation of tall "munj" grass and various small shrubs.

53. **Economic.**—In addition to iron, kaolin and steatite (see paras. 26, 34), Mr. Heron records some trifling occurrences of mica; quartz is also referred to and the garnet workings long since closed, at Toda Rai Singh and other villages to the south and west of Rajmahal.

54. **Mr. N. D. Daru: Dungarpur.**—The survey of the State of Dungarpur was continued by Mr. Daru, who attributes most of the rocks met with to the Aravalli system, the chief types include ortho-gneisses, schists, phyllites, quartzites, boulder-beds and crystalline limestones; Mr. Daru has not yet been able to subdivide these.

Burma.

55. **Mr. P. N. Datta: Kyaukse and Meiktila.**—Mr. P. N. Datta was engaged in the survey of the eastern parts of the Irrawadi valley lying in the districts of Kyaukse and Meiktila and bounded on the east by the hills of the Shan States. The rocks met with consist of young clastic deposits, referred to the Pegu series on the west, and a group of older sedimentary rocks intimately associated with and altered by intrusive granite on the east. The older rocks consist of shale, sandstone and limestone, all frequently metamorphosed; in the absence of fossils, there is no evidence of their age, but Mr. Datta suggests that it may be Palæozoic. Felsite and andesite are also said to occur in this region, but their relationship to the other rocks is not stated.

56. **Mr. G. de P. Cotter: Yenangyaung and Minbu.**—While acting as "Oilfields Officer" at Yenangyaung during the early part of the year, Mr. Cotter visited the steatite mines in the Arakan Yoma and made some notes on the country traversed; no new facts, however, were brought to light. During the latter part of the year, he took up the systematic geological survey of the western part of the Minbu district including Hpa-aing and the eastern flanks of the Yoma; rocks of eocene and of so-called "lower eocene" age were found, the former yielding the usual "Khirthar" fossils. Serpentine intrusions are numerous. Owing to the unhealthiness of the season, Mr. Cotter was obliged through illness to interrupt his work, temporarily transferring operations to a less malarious area until the season should be more advanced.

57. **Mr. H. S. Bion: Upper Chindwin.**—During the latter part of the year, Mr. Bion took up a survey of the auriferous gravels of the Chindwin. His work has been noticed under *Gold* (para. 24).

58. **Sub-Assistant Sethu Rama Rau: Minbu and Pakokku.**—Sub-Assistant Sethu Rama Rau continued the mapping of the Tertiary beds on the west of the Irrawadi in the districts of Minbu and Pakokku. He completed the survey of the area covered by sheets 84 $\frac{K}{11}$ and 84 $\frac{K}{15}$ with the exception of the part already surveyed by Mr. Cotter. In the Minbu district he added the geology to parts of sheets 84 $\frac{L}{5}$, $\frac{L}{6}$, $\frac{L}{9}$ and sheet 110.

59. **Burmo-China Frontier.**—The results of the geological traverses made by Mr. Coggin Brown a few years ago in the neighbourhood of the Burmo-China frontier about Teng-yueh have now been embodied in a paper which will be published in a subsequent part of these *Records*.

60. The rocks met with are classified by Mr. Brown into six subdivisions, *viz.* (in descending order)—

(6) Recent deposits;

(5) later Tertiary deposits of the Taping, Möng-hsa Möng-wan and Teng-yueh valleys;

(4) eruptive volcanic rocks of the Teng-yueh area;

(3) metamorphic rocks of the Kao-liang series;

(2) intrusive granites of the upper Taping valley;

(1) gneisses, schists and crystalline limestones of the frontier hills.

61. The crystalline series (1) covers the greater part of the country between Bhamo and the Salween; in the neighbourhood of Teng-yueh it is hidden as a rule by younger bedded deposits, but inliers of the old crystalline surface often appear. Granite (2) also occurs in considerable quantity.

62. The metamorphic series (3) consists of quartzites and phyllites, very similar to, and probably of the same age as, the Chaung Magyi series of the Northern Shan States.

63. The eruptive volcanic rocks, of which a separate description has been written by Mr. R. C. Burton (*supra*, para. 4) consist of andesites, basalts and pumice. They fall into an "older" and a "newer" group, the former consisting of grey, close-grained porphyritic andesites, which have a characteristic platy structure and are often folded. They are much older than the members of the "newer" group, although no age is assigned to them, but Mr. Brown seems to contemplate the possibility of their being as old as Palæozoic. The newer group consists of massive andesites, which are of Tertiary age and are again older than the black slaggy lavas of the still existing, though no longer active, vents.

64. The later Tertiary, as well as the Recent, deposits of interest are chiefly of lacustrine origin, the older being similar to those of the Northern Shan States and Tongking and probably of late Tertiary, and perhaps partly pleistocene, age.

65. Hot springs are very numerous in the district of Teng-yueh and are regarded as the last manifestations of the earlier intense volcanic activity.

Central Provinces.

66. **Dr. L. L. Fermor and Mr. C. S. Fox: Chhindwara district.**—During the early part of the year, work was carried out by Messrs. Fermor and Fox in the valley of the Kanhan river and its bordering hills. Owing to the intricacies of the boundaries between the Deccan Trap and the Archæan granites and gneisses and the thickly wooded and sparsely inhabited character of the ground investigated, work was necessarily slow, but a total of some 300 square miles was mapped on the one-inch scale (sheet 53, C. P. Survey).

67. **The Archæan floor below the Deccan Trap.**—There is nothing to add to the account of the Deccan Trap formation given in the previous report, except to refer to the gradually decreasing elevation of the base of this formation as one passes from north to south. Thus, near Pardhan Ghogri the elevation of the base of the trap is 2,075 feet, whilst at Koprawari, only some 13 miles further south, it is about 1,400 feet. At the northern end of the valley the Archæan rocks are found to join the main strip of granites running westward from Chhindwara. It is evident from this and from the fact that granites and gneisses crop out on the Satpuras to the east of Seoni, that the Satpura range, which at first sight appears to owe its elevation to the presence of superposed flows of Deccan Trap lavas, is really a feature of the pre-Trap Archæan surface. Although there is a gradual decrease in the elevation of the

boundary between the Deccan Trap and the Archæan in passing from north to south, yet this change of elevation is locally very irregular and by means of aneroid readings it has been possible to detect many features of the pre-Deccan Trap topography. Thus the basal flow of Deogarh Hill and the underlying Lameta sediments, with those to the south-west of this hill, occupy an old river valley at least 50 feet deep.

68. **Nature of Lameta rocks in Chhindwara.**—Detailed examination of this boundary is necessary owing to the local variations in the thin band of rock usually intervening between the Deccan Trap and the underlying gneisses. This band must be correlated with the Lametas, since it agrees in many respects with occurrences seen in other parts of India; but as the result of detailed work it has been found that by far the larger proportion of this Infratrappean formation is not a sediment, but a rock of chemical origin formed either by the silicification or by the calcification of the underlying gneisses. Every gradation has been found from a fresh porphyritic gneiss, through a similar rock partially veined by chert and calcite, to a more completely replaced stage, in which the gneiss is seen in isolated patches in a network of secondary calcite, finally passing into a capping of typical siliceous limestone, to be distinguished in no way from the Lameta limestone of other parts of India.

69. **At Lameta Ghat.**—In November 1912, Dr. Fermor paid a brief visit to Lameta Ghat in the Jabalpur district, the original locality from which the rock took its name; here he found the limestone to be lithologically indistinguishable from the final products of the calcification of the gneisses in Chhindwara. The limestone of this locality rests, however, upon the sedimentary Jabalpur series of the Gondwana system; it will therefore be necessary to make a very careful study of the Lameta outcrops at Lameta Ghat and near Jabalpur in order to solve this problem satisfactorily. Meanwhile it is interesting to note that in thin sections under the microscope the limestone of Lameta Ghat itself shows evidence of secondary calcification. Provisionally, therefore, it may be regarded as probable that a considerable, if not large, proportion of the rock mapped as Lameta in different parts of India is of chemical origin. This would explain the extraordinary scarcity of fossils in the Lameta formation. A great variety of rocks have been found thus, replaced either by silica or by calcite. Amongst them may be enumerated several varieties of granite and gneiss, also hornblende-schist and crystalline limestone.

70. **Sedimentary Lametas.**—The detailed work along the Infratrappean boundaries has shown, however, that true sediments also occur. These are usually grits of various degrees of coarseness and are probably to be referred to the Lameta formation. At two localities Dr. Fermor succeeded in finding fossils. One of these was a specimen

of *Turritella?* in a piece of silicified rock near the hamlet of Kotmi, but a prolonged search did not lead to the discovery of any further specimens, whilst numerous specimens of *Paludina* were obtained from a siliceous grit at the second locality (about two miles north-west of milestone 23 on the Chhindwara-Nagpur road). The only exposure of the Lameta formation of any considerable size is that occupying the valley to the south of Deogarh Hill: it consists partly of grits and partly of clays.

71. The evidence concerning the date of formation of these calcareous and siliceous rocks is not yet regarded as conclusive by Messrs. Fermor and Fox, but in all probability the silicification was effected by solutions derived from the overlying Deccan Trap formation. It is possible that the Lameta limestones have been formed by the superficial replacement of the gneisses prior to the eruption of the Deccan Trap and the deposition of the sedimentary Lametas. If this deduction be correct the calcification and the silicification of the gneisses must be assigned to different periods, the silicification due to the Deccan Trap having affected both the fresh gneisses, the partially calcified gneisses, the so-called Lameta limestones, and the true Lameta grits, fossiliferous and unfossiliferous. In one place this silicification by the Deccan Trap was found to be accompanied by the introduction of heulandite into both the gneisses and the silicified limestones. But, on the other hand, it is much more probable that the calcification has been effected by solutions derived from the overlying Deccan Trap, in which case the calcification and silicification are to be regarded as two stages of one series of chemical processes.

72. **The Archæan rocks.**—The Archæan rocks in the area mapped are almost entirely granites and ortho-gneisses, metamorphosed sediments being practically absent, until the south-east corner of the sheet is approached, where, in the neighbourhood of Nautal, crystalline limestones are found in great variety. The Archæan gneisses are divided into two sections by a zone of intense crushing marked by rolled out and mylonitized gneisses stretching for 15 miles in a west-south-west direction from a point two miles south of Monkher to a point two miles south-south-west of Dhanora. This zone of crushing is accompanied by a strike fault, and the gneisses have been locally brecciated, and to a large extent replaced by white vein-quartz. In the eastern section this fault-breccia is from 50 to 100 feet wide and gives rise to steep bluffs and well-marked ridges; but in the western section it is either completely absent or only from a few inches up to 5 feet wide. The rock immediately north and south of the quartz-breccia is a hornstone-like rock, which, being really a mylonitized gneiss, has been termed hornstone-gneiss. This belt of crushing extends for about a mile to the north of the quartz reef, the degree of mylonitization of the gneiss decreasing with distance from the quartz-breccia. The mylonitized gneisses are succeeded to the north by intimately

associated porphyritic pink biotite-gneisses and melanocratic biotite-hornblende-gneisses rich in sphene. Still further north the foliation becomes less marked and the rocks may in places be termed porphyritic granites. On the south side of this quartz-breccia reef the rocks are mylonitized for a short distance and then give place to well-foliated schistose biotite-gneisses; and from the field evidence obtained it is deduced that the typical schistose biotite-gneisses of the Sausar Tahsil of this district may be merely foliated forms of the porphyritic granites of Chhindwara. The belt of crushing seems to be a fairly sharp dividing line between the porphyritic granite on the north, with its mylonitized and rolled-out derivatives, and the schistose gneisses on the south. Whereas the terms granite and gneissose granite would frequently be applied to the rocks on the north of the fault, the term gneiss is more generally applicable to those on the south.

73. **Their mutual relationship.**—Amongst the rocks south of the fault there are many varieties extremely rich in hornblende with every gradation between coarse-grained biotitic and coarse-grained hornblendic gneiss, whilst near Nautal a small area of true syenites has been found. Several occurrences have been found, also, of microcline-rocks, which must be regarded as an extreme variety of syenite. In many places throughout the Kanhan valley and that of the Nakta nala there are intrusions of pegmatites and of rather fine-grained granites, and although both these rocks seem to be on the whole distinctly younger than the porphyritic granites and their schistose and gneissose derivatives, yet the evidence obtained indicates a general relationship not only between the fine-grained granites and the pegmatites, but also between each of these rocks and the porphyritic granites and associated gneisses, and points to the probability that all these granites and orthogneisses are magmatic relatives and have been derived from one magma. This idea, however, of a common magmatic origin does not preclude the possibility that some of the gneisses may be of considerably greater age than the porphyritic granites and their derived gneisses.

74. **Pegmatites.**—The pegmatities are of considerable interest. Some of them contain only pink potash-felspar, whilst others contain both potash felspar and a white plagioclase, and still others contain only the plagioclase. Some of the pegmatite dykes are very coarse-grained in parts and have the constitution of fine-grained granites in other parts; one dyke in the Nakta nala consists centrally of a fine-grained granite, whilst both edges are very coarsely crystalline and have in places the constitution of a graphic granite.

75. **Epidiorites and basalt dykes.**—In the neighbourhood of Lawaghogri Mr. Fox found a series of lenticular outcrops of epidiorite intercalated along the foliation planes of the gneisses. They show every

gradation between a slightly altered dolerite and a hornblende-schist. In the same neighbourhood Mr. Fox has also traced several basalt dykes of Deccan Trap age traversing the Archæan rocks. In one case, near Naraingbat, one of these dykes is directly connected with the overlying flow of basalt.

76. **Continuity of fault.**—The belt of mylonitization and fault-breccia already referred to is covered over at either end by the Deccan Trap lava flows and it is probable that it continues for some distance beneath the trap. If it continues to the north-east it should, if still existent, reappear somewhere in the neighbourhood of Seoni.

77. **Mr. Walker: Betul district.**—Mr. Walker was engaged in surveying the parts of the Betul district represented by standard sheets (1″=1 mile) 36, 37 and 53. The rocks met with belong to the same general groups as those of Chhindwara and include chiefly gneisses, Dharwar schists and Deccan trap, with Infratrappean and Intertrappean beds in places. To the south of a line drawn from Nilajhar (21° 55′; 78° 32′) to Amla (21° 55′; 78° 10′), the only rock found is Deccan trap, whilst to the north of this line gneisses and schists occur. On the whole, the gneisses play only a subordinate part; they consist of schistose biotite-gneiss with occasional patches and veins of aplite and intrusive masses of epidiorite and hornblende-schist. Dharwar schists are infolded with the gneiss along its margins. The Dharwar rocks comprise three general types, *viz.*, argillaceous sediments, as represented by phyllites, to the north of Kalmeshara (22° 2′; 78° 21′); micaceous quartz-schists and quartzites (metamorphosed arenaceous sediments) to the south of the same place; and old intrusive rocks now represented by epidiorites similar to those of the Kanhan valley, and found at Bordhai (22°; 78° 23′) and Harnia (21° 59′; 78° 22′).

78. Of the Infratrappean beds, Mr. Walker regards five small exposures, consisting of conglomerates, grits and clays, as perhaps of true sedimentary origin; between Nilajhar and Banga (21° 55′; 78° 25′) the trap is usually underlain by limestone and chert, which, as in Chhindwara, are regarded as due to secondary replacement of the underlying crystalline rocks through the contact action of the trap.

79. The Deccan trap is from 400—500 feet thick; the upper and lower flows are vesicular and crowded with geodes of quartz and chalcedony, but zeolites are rare. A slight dip to south-west has been noticed in the basalt flows. Basalt dykes have been found penetrating the crystalline rocks.

80. Intertrappean beds occur at three horizons; they are of the usual type and are often fossiliferous.

81. The schists and gneisses of the Bel valley show signs of considerable disturbance: faults are common, and, in the Dharwar schists, are

accompanied by brecciation; this has given rise to a series of ridges, which form conspicuous features in the local topography.

82. **Sub-Assistant Vinayak Rao: Seoni district.**—After accompanying Dr. Fermor for some six weeks and having become familiar with the sections in the Nakta nala, Sub-Assistant M. Vinayak Rao was sent to commence work on sheet 90 in the Seoni district, with special instructions to search for the continuation of the strike-fault and belt of crushing. He succeeded in finding crushed gneisses and in one place a breccia, approximately where expected. But the dynamic effects seem to be feebler in Seoni than in Chhindwara and split up into more than one belt. In conformity with this the general distinction between more granitic rocks on the northern side of the crush zone and more gneissose rocks on the south is less readily apparent than in the Kanhan area. In the time at his disposal Mr. Vinayak Rao nearly completed a preliminary survey of the whole of this sheet, the boundaries between the Deccan Trap and Archæan rocks being largely obscured by soil. To the south of Seoni a considerable area of laterite was discovered resting on the Deccan Trap, the thickness of the laterite being in one place as much as 140 feet.

83. In his progress report Mr. Vinayak Rao reports the discovery of two dykes near the village of Suktara, two miles north-west of Kanhiwara Railway Station. These have each a very irregular course and vary in width from a few inches to $2\frac{1}{2}$ feet; they are of tachylytic character, with chilled glassy borders.

Kashmir.

84. **Messrs. C. S. Middlemiss and H. S. Bion: Kashmir.**—During the summer months Mr. Middlemiss, with the assistance of Mr. H. S. Bion, continued the revision of the geology of Kashmir. Work was taken up in the neighbourhood of Srinagar and continued round the north end of the valley, including also a portion of the Kishenganga drainage, during the first months of the season, and afterwards in the direction of the Marbal, Hoksar and Changam passes at the south-eastern extremity of the valley. Extensive new collections from the various old and some new horizons of the Silurian-Trias sequence have been made, and the mapping of the area in as much detail as possible carried on to a point where another season, it is hoped, will see the conclusion of the revised survey of the valley of Kashmir proper, that is to say, of all that portion lying within the Jhelum drainage area. It is also hoped that the new $1'' = 1$ mile maps recently made by the Survey of India will be used in this work, which will serve as a valuable basis for the larger and more difficult task of mapping the complicated metamorphic areas to the north, including Baltistan, the Karakoram and the Hindu Kush,

85. Among special results attained, the following may be mentioned: at Tregam (Trigamma) the limestone masses, as also those shown at intervals beyond to the north into the Kishenganga drainage and west again near Zunaresh, were found to be interbedded with the old slate system, and not to belong to the Zanskar system. This was verified by finding at several horizons in the slates interbedded with the limestones a Silurian *Orthis* fauna similar to that of Gugaldar, Gudramer and the Margan pass; the agglomeratic slate series, which comes between the Fenestella series and the Panjal Trap, and which hitherto had yielded no fossils, has now been found to contain at least two life zones, one coming a few feet below the base of the Panjal Trap and the other much lower down. Both are characterised by a rich *Syringothyris* fauna, together with a *Spirifer* allied to *S. Lydekkeri* Dien., *Fenestella*, *Productus* and *Camarophoria*. The lower horizon has so far been found only in the Marbal valley on the way towards the pass; it is very rich in material and of considerable thickness. The upper one is much thinner and is found in the Marbal valley and also at Nagmarg in Lolab.

86. A *Glossopteris* flora, with *Gangamopteris* and *Psygmophyllum*, has also been found just below the Panjal Trap in the Nagmarg sections.

87. In the Manasbal and Bandipur sections, Lydekker's conclusion that no Kuling series is there represented above the Panjal Trap was confirmed, and the most probable inference drawn that the volcanic activity of the Panjal Trap epoch extended up to the base of the Upper Trias in those parts, whilst again in the Imbersilwara hill mass, trap appears to be interbedded with the Upper Trias in a remarkably clear section.

88. A very rich Muschelkalk fauna has been found at many new places in the south-eastern part of the valley. In the Marbal valley the section from Karbodra down to Prumu in the Tansan river shows a wonderfully clear exposure, of about 20,000 feet thickness, through the Silurian-Trias sequence in fine normal folds of 15,000 feet double amplitude.

89. It is difficult to exaggerate the importance to Himalayan stratigraphy of the many discoveries made by Mr. Middlemiss in Kashmir during the last few years, for they have led to the solution of all those vexed questions which have hitherto barred the way to a satisfactory correlation of the various systems in the Jhelum basin with their less complicated representatives in Spiti and Kumaon. Of the work now under review the most striking feature is the complete manner in which Mr. Middlemiss has worked out the age of the Panjal Trap which he has shown to extend from Lower Gondwana to Upper Trias in some places, whilst disappearing in others at the end of the Permian period.

Punjab.

90. **Dr. G. E. Pilgrim: Salt Range.**—From February until May 1912, Dr. G. E. Pilgrim was at work on the northern edge of the Salt Range, where he mapped in detail the ossiferous areas round Chinji and between Hasnot and the river Jhelum, collecting fully from the various stratigraphical zones. The following results of his observations are regarded by Dr. Pilgrim as of chief importance:—

(1) the occurrence at a low horizon in the Middle Siwaliks at Nagri of a fossil fauna believed by Dr. Pilgrim to be intermediate in character between that of Dhok Pathan and that of Chinji;

(2) the apparent absence of *Hipparion* from the lower 1,500 feet of the Chinji beds;

(3) the existence of unfossiliferous strata of Siwalik type, 1,700 feet thick, below the Chinji fossiliferous zone. This had previously been noticed by Mr. Vinayak Rao, who had, however, assigned the beds to the Gaj;

(4) in the Chambal ridge near the Jhelum river, a very distinct unconformity between the Upper and Middle Siwaliks. Many feet of Middle Siwalik strata are entirely missing including the fossiliferous horizon of Hasnot, the equivalent of that of Dhok Pathan. Going towards Hasnot the upper beds gradually come in, and the unconformity diminishes, though it is nowhere, perhaps, entirely absent;

(5) the fossils of the basal beds of the Upper Siwaliks at Tatrot, Kotal Kund, and some other localities have been erroneously united by previous collectors with those of the Middle Siwaliks of Hasnot, and Dr. Pilgrim now considers it necessary to remove from the Middle Siwalik fauna *Hippohyus*, *Sus giganteus*, certain bovines allied to *Bos* and *Anoa* and most of the *Hippopotamus* remains. These occur in the basal beds of the Upper Siwalik associated with *Hipparion*, *Stegodon*, and *Mastodon sivalensis*, it being noteworthy that no trace of either *Equus* or *Elephas* has been found.

91. Dr. Pilgrim considers that these facts, taken in conjunction with the recent discovery by Dr. G. Schlesinger of *Elephas planifrons* in a low zone of the middle pliocene near Vienna, afford additional evidence for the pontian age of the Middle Siwalik fauna of Dhok Pathan and Hasnot. He proposes the following classification for the Siwaliks of the

Salt Range, based partly on his past season's work and partly on the collections made from the Simla hills in 1911 by Mr. Vinayak Rao :—

			Feet above base.
Upper Siwalik	Boulder-bed zone.	With *Camelus Equus, Elephas hysudricus.*	15,000—17,000
	Pinjor zone .	Pebbly sandstones with *Hipparion* and *Elephas planifrons.*	11,500—15,000
	Tatrot zone .	Conglomerates and grits with *Hipparion, Hippopotamus, Hippohyus* and *Mastodon sivalensis.*	10,000—11,000
Middle Siwalik	Bhandar beds .	Unfossiliferous sandstones and clays.	9,500—10,000
	Dhok Pathan zone.	Sandstones and clays with *Mastodon, Stegodon, Tetrabelodon, Hipparion,* large antelopes and giraffoids and *Tragocerus.*	8,500—9,500
	Nagri zone .	Sandstones and clays with *Hipparion,* large antelopes, *Giraffokeryx* and a large giraffoid.	5,500
Lower Siwalik	Upper Chinji zone.	Red nodular clays and sandstones with *Tetrabelodon, Hipparion, Hyæna, Hyotherium, Giraffokeryx, Protragocerus,* and a large antelope.	3,200—4,000
	Lower Chinji zone.	Red nodular clays and sandstones with *Tetrabelodon, Hyotherium, Giraffokeryx, Protragocerus* and small antelopes.	1,700—3,200
	Lower Manchhar zone.	Sandstones and concretionary beds, unfossiliferous in the Salt Range: in Sind with *Brachyodus* and *Hyoboops.*	Basal beds.

GEODESY.

BY

LIEUTENANT-COLONEL G. P. LENOX-CONYNGHAM, R.E.,
Superintendent of the Trigonometrical Survey.

PRINCIPAL TRIANGULATION.

Bengal and Madras.

Orissa Division and Ganjam District. The Sambalpur Series.

At the time of submission of last year's report to the Board of Scientific Advice, this series, which emanates from the Calcutta Longitudinal Series in latitude 23° 30′, longitude 85°, had been carried southward along the meridian of 84° as far as latitude 22°, to a point about 30 miles north of Sambalpur. During the season 1912-13, the series has been extended, still following the same meridian, through Sambalpur, the Orissa Feudatory States, the Khondmals and into the Ganjam District of the Madras Presidency, reaching a mean latitude of 19° 30′.

The heavily wooded, inhospitable, tractless country through which the triangulation had to be carried, put many difficulties in the path of the observer and gave promise of but slow progress. Nevertheless, two quadrilaterals, two tetragons and one hexagon were fully completed while a third quadrilateral was partially observed, extending the series by 167 miles. The area covered by these figures is 5,014 square miles.

The observations were made with Messrs. Troughton and Simm's 12 inch micrometer theodolite No. V. The average triangular error exhibited by the 22 triangles is small, 0·185″, the largest triangular error amounting to only 0·564″.

Two astronomical azimuths were observed, one at Sendur in latitude 20° 16′ and the second at Andhari in latitude 21° 58′.

After March 15th, no observing was possible on account of the haze and the smoke of forest fires, and operations had to be suspended.

Of this series, three more figures remain to be completed to effect a junction with the East Coast Series in the neighbourhood of Parlakimedi.

SECONDARY TRIANGULATION.

Central Provinces.

Nimar and Betul Districts and Central India Agency. (Indore State.)

To meet present topographical needs, secondary operations were commenced in the western portion of the Central Provinces and in the Central India Agency.

The Khandwa Series

This series, 141 miles in length, has been carried along the parallel of 22° between the Great Arc Series in longitude 78° and the Khanpisura Series in longitude 75°. It consists of 22 triangles covering an area of 1,820 square miles.

The observations were made with an 8 inch micrometer theodolite. The average triangular error was found to be 1·41″.

The Ākola Series.

This is a meridional series emanating from the Khandwa series in longitude 76° 30′. During 1912-13, only the first four stations were selected and built. The series will be carried southwards during 1913-14 to effect a junction with the Bir Series in latitude 19°.

Eastern Bengal and Assam.

The Manipur Series.

A commencement has been made on a secondary series which will connect the Assam Valley triangulation with the Manipur Meridional Series. It will eventually form part of the latter and the observations have, therefore, been carried out with a 12 inch theodolite similar to that used on the Manipur Meridional Series.

In March, low-lying haze covered the country through which the triangulation was being carried and rendered further observations impossible. Had it not been for the unfavourable atmospheric conditions, the series would have been completed. Seven triangles still remain to be observed.

Khasi Hills. The Khasi-Garo Hills Series.

In 1909-10, the Khasi and Jaintia Hills secondary series were run west and east from the Eastern Frontier Series in latitude 25° 30′. As,

however, this latter series was known to have been seriously disturbed by the earthquake of 1897, the positions of stations of the secondary series could be considered as only provisional until a connection could be made with a principal series further to the westward, out of the disturbed area. The opportunity to effect this connection was not forthcoming till this last season, when the Garo Hills secondary series was completed, joining up the Khasi and Jaintia Hills series with the Brahmaputra Meridional Series. The co-ordinates of points of all three secondary series will be recomputed, using the data afforded by the latter principal series.

Bombay.

Bombay City and Island Triangulation.

This triangulation, to serve as a framework for a large scale city survey, was commenced in 1911-12. It has now been completed and supplemented by precise traverse work. The framework comprises 112 permanent points distributed over the city and island. The positions of 65 of these have been determined by triangulation based on a side of the Bombay Longitudinal Series. Of the remaining points, the co-ordinates of 26, situated in the southern and central portions of the island, have been found by running traverses between the triangulated points. The positions of 21 points in the northern part of the island still remain to be determined by traverse.

On account of the difficulty of devising and erecting signals for observation in the densely crowded portions of the island, the determination of co-ordinates by the methods of triangulation could not be effected for all the points it was proposed to introduce into the framework. Recourse had, therefore, to be made to traverse operations. To obtain the requisite degree of precision, the steel 100 ft. tapes which were used (invar tapes not being available at the time) were compared daily with a standard of length laid down between brass plates set in the verandah floor of a suitable building; the temperatures of the tapes were determined from time to time during the day's work; the tapes were strained by the action of weights suspended over pulleys and auxiliary apparatus, reference marks, observation signals, etc., were specially designed.

In the computations, corrections for the temperature of the tape at the time of observation have been applied and all linear measurements have been reduced to terms of the standard length.

Final results are not yet available, but it may be of interest to note that the difference found between two linear measurements of the same traverse line made on different days amounted to 0·06 ft. in 5,131 ft., the ratio of difference to length measured being thus 1/85,500.

Kashmir.

Indo-Russian connection. Hunza Valley.

In 1909, the International Geodetic Conference passed a resolution embodying the desirability of establishing a junction between the Indian and Russian systems of triangulation. Accordingly, during the summer months of 1911, reconnaissances were undertaken of the country intervening between the Kashmir Principal Series and the Pamirs with a view to discovering a practicable route to be followed in making the connection. Three schemes were suggested to the officers entrusted with the reconnaissances. The first was to extend the Kashmir Principal Series as far as the Sakiz Jarab range, on which stations would be established to the east of the Darkot pass. From these points, it was hoped, observations might be made to Concord and Salisbury peaks on the Afghan Russian border, which peaks would be included by the Russian observers in their triangulation on the Pamirs. The investigation of the practicability of this scheme was undertaken by the late Lieutenant Bell, R.E. He reported that the main chain of peaks of the Sakiz Jarab range was inaccessible and that the hills immediately to the south, only a little less difficult to negotiate, though they offered a satisfactory view to the north, were hidden from the south by high inaccessible masses effectually obstructing triangulation carried from the terminal points of the Kashmir series.

A second scheme involved the carrying of secondary triangulation from the principal series up the Yasin and Karamber valleys to the neighbourhood of the Gazan and Bhort passes, from which the Concord and Salisbury peaks might be visible. It was found that such triangulation could be carried as far as Harmot, but that, beyond this place, the valley narrows between precipitous hills to such an extent as to render further progress impossible.

The third alternative scheme was for secondary triangulation to break off from the principal series just south of Gilgit and to follow the Hunza and Kanjut valleys as far as the Kilik and Minktaka passes and from thence to extend over the Taghdumbash Pamir to a junction with the Russian points. This was found to be practicable. The valley as far as Hunza is comparatively open and the hills, though difficult, not inaccessible. Beyond Hunza, though the valley narrows somewhat, fairly well-conditioned figures can still be laid out as far as Misgar. Here in order to obtain triangles of sufficient length of side the series has to turn westward, out of the valley, and, bending again in a northerly direction, approach the Kilik pass from the south-west. From this pass the triangulation can be easily carried across the Taghdumbash Pamir to the Russian points near the Beyik pass.

It proved to be impossible to complete the whole of this connection in the season of 1912. The season was a short one and the detachment was continually hampered by unfavourable weather. Further, the death of Lieutenant Bell, R.E., who was in charge of the operations, caused a short cessation of the work and a dislocation of the arrangements made for its execution. The whole course to be followed by the triangulation was, nevertheless, reconnoitred in detail and, except for a distance of some 30 miles, the stations were selected and built. At a few of the stations at the northern and southern ends of the series observations were completed.

Operations were suspended between the end of October 1912 and May 1913, when the detachment returned to complete, it is hoped, the observations remaining to effect the desired connection.

Note on the Base Line Apparatus of the Survey of India.

As the Survey of India is now, after an interval of 32 years, about to turn its attention once again to base line operations, it may, perhaps, be of interest to review the past connections of the Department with work of this nature, more particularly in regard to the apparatus used, and to consider briefly the methods and equipment that will be employed in the measurements about to be undertaken.

When considering the past base line operations of the Survey of India, we find they fall into two groups, one covering measurements made between 1800 and 1825 and the second those between 1830 and 1870. From the end of the period covered by the second group till the present time, excepting one base measured in 1881, no operations of the kind have been undertaken.

We are now on the eve of a period which will give us a new group.

The triangulation has extended both to the east and to the west considerably beyond the network controlled by the base lines of the second group and additional lines for the verification of the new figures have been among the most prominent of geodetic desiderata during the past decade.

Between 1802 and 1825, during the first phase of development of the Survey of India, eleven base lines, the first operations of the kind carried out in India, were measured by Colonel Lambton. They were used to control the great network of triangulation which was then being extended over the southern portion of the peninsula, from Cape Comorin as far north as the parallel of 19°, for the purposes both of geodetic research and of topographical surveying. Below the latitude of 16°, eight of these base lines were distributed at intervals of from 90 to 250 miles over the whole area of the peninsula. The remaining three lines were

situated close to the meridian of 78°, between latitudes 16° and 24°, and were intended as checks to triangulation carried out mainly for geodetic objects.

The apparatus then available consisted of two 100 ft. steel chains, by Ramsden, and a 3 ft. brass scale made by Cary. One of the chains, received by the Survey in 1802, having been compared with the "standard in London" was never used in the field, but was maintained as a standard of reference with which the older chain was compared from time to time. This latter chain had a curious history, having been originally destined as a present to the Emperor of China and refused by him. It was afterwards taken to Calcutta where it was bought by Lord Clive, then Governor of Madras, and made over to Colonel Lambton.

The manner in which the measurements were performed was not always the same. At some of the base lines the chain was laid in a series of five wooden coffers, supported on posts and adjusted to the horizontal from end to end. The chain was strained by the weight of an 8½ inch shell suspended from the forward end, the rear end being attached to a post by a device which permitted of adjustment of the rear defining mark over a reference mark on the ground. The transference of the defining marks to the ground was effected by means of a plummet. Five thermometers were placed alongside the chain in the coffers and the mean temperature indication was recorded. At other bases, the coffers were dispensed with, and the chain, laid on the ground carefully prepared beforehand, was strained by two small capstans. The tension thus produced could not be estimated nor regulated.

As linear units for geodetic survey, these chains were unsatisfactory. During the latter half of the period of their use, doubt gathered about the assumed invariability of the standard chain. There was no satisfactory means of checking its length and, in addition, there arose uncertainty as to the unit that had been employed in laying off its original length. Efforts were made to determine the amount of variation of the chain by periodical comparisons against a 100 ft. length laid off on a low wall by means of Cary's 3 ft. brass scale and a large beam compass, a procedure not calculated to lead to results of the precision requisite in operations of this nature. The results of these experiments threw suspicion on the accuracy of the comparisons and on the value assumed as the original length of the chain and led to a decision to reject the bases measured with it, as being insufficiently accurate for geodetic purposes and to obtain more efficient apparatus for the measurement of new lines on which to base the geodetic triangulation. This decision put a period to the first group of base line operations.

For the measurement of the lines which form the second group, the survey acquired, about the year 1830, two standard 10 ft. bars of wrought

iron and the Colby apparatus of compensated bars and microscopes. The bars were designated A and B and were of simple design. The section was a rectangle, 2 inches in depth by rather less than 1 inch in breadth, the ends of the bars being cut away to half their depth to allow of the defining dots, marked on platinum plugs, being placed in the neutral axis. Each bar was supported by rollers at one-quarter and three-quarters of its length.

Bar A became the Indian 10 ft. standard while Bar B appears to have been used as a means of comparing the Indian standard with those of other geodetic surveys. Bar A remained in India till the year 1908 and was used at the eleven base lines measured between 1832 and 1870, and in 1881. In February 1908 it was sent to Sevres to be compared with the international metre and returned to India in November of the same year. Bar B was sent to England in 1843 and was made over to the Ordnance Survey. Between that date and 1865, it was compared with the Ordnance standards and, by Captain A. R. Clarke at Southampton, with the 10 ft. supplementary bars $/_B$ and $/_S$ which were made for the Great Trigonometrical Survey in 1864.

From these comparisons, the relation between Bar A, defining 10 Indian feet, and the English standard yard was found to be—

Bar A = 3·33331886 times the yard at 62° F.

This value was determined by combining Captain Clarke's results with quantities observed by officers of the Great Trigonometrical Survey at Dehra Dun. Into its derivation, comparisons involving the Bars B and / were necessarily introduced.

Viewed in the light of modern comparisons, the precision of this quantity cannot be highly rated. The comparison was not a direct one; it was built up of observations some of which were made in 1865 at Southampton, others between 1867 and 1870 at Dehra Dun. Between the two periods, the bar $/_S$, which formed a link in the chain of comparison, made the voyage from England to India, and whether, during the period between the observations in England and those in India, the bar underwent any change of length there was no means of ascertaining. The bars were of materials possessing large coefficients of expansion and the precise determination of their temperatures during comparison was of the highest importance; the means then available, however, of ensuring steadiness of temperature and of providing that the thermometer reading should truly indicate the temperature of the metal bar must, to-day, be considered imperfect. In addition, judged by modern standards, the defining marks on Bar A cannot be held to admit of precise comparison. These marks are dots graved by a needle in platinum plugs and, when compared with the fine lines cut on a modern standard, they appear of excessive size, imperfect both in quality of outline and in shape.

However, this question of the relation of the Indian to foreign standards was, at the time, mainly academic. The uniformity of unit that now exists among associations and departments occupied in geodetic research had not yet established itself. There was no necessity for the reduction of our measurements to terms of any foreign unit. Bar A was accepted, not as an intermediary, but as the ultimate unit, whatever its length might be, of the Indian Survey. The junction of the Indian Survey with foreign operations was a factor so distant in the future as to be of negligible weight in considering methods and equipment.

The lengths of the base lines were first measured by the Colby apparatus and afterwards reduced to terms of Bar A by means of the relation of the Colby bars to this standard. The Colby apparatus consists of a set of six compensated bars and microscopes, the lengths of each of which was determined by comparison with the standard. A detailed description of the apparatus and the method of its use is given in the departmental records and it will be sufficient to remark here, that the term "compensated" was used in view of the fact that, in the construction of the bars and microscopes, advantage had been taken of the differences of the thermal expansions of brass and iron to devise an apparatus which would, theoretically, indicate a certain invariable length unaffected by changes of temperature.

The comparisons between the Colby bars and the standard A were made by bringing each bar in succession into the line joining the focal points of two microscopes erected, at a distance apart closely approximating to 10 ft. on masonry pillars. Micrometer measurements were then made with each microscope to the defining dots of the bar adjusted below it. A comparison of the measurements thus made gave the linear relation between the bars. The temperatures of the latter were assumed to be those indicated by thermometers, the bulbs of which were placed in small wells cut in the body of the bar and filled with mercury or oil to provide contact between the metal of the bar and the bulb. Some provision was made to procure steadiness of temperature during the comparisons by enclosing the bars in wooden cases, by protecting the comparison room from the sun's rays and by preventing the admission of the outer air.

Between 1832 and 1869, ten bases, all but one of lengths varying from 6·4 to 7·9 miles in length, were measured with this apparatus, one of them being the old chain measured base at Sironj. They served to control the geodetic triangulation which, in 1870, had extended over the whole of India Proper. Since 1870 only one base line has been measured. This was in 1881, at Mergui, to provide a linear datum for the operations about to be carried over Burma.

On these eleven bases, from 275 to 750 miles apart, depends the whole of the triangulation of the Survey of India, as it now stands.

During the last thirty years this triangulation has spread over Burma, on the east, and Baluchistan, on the west. In the north-east of Burma the triangulation has reached a point 700 miles from the nearest base in India and 1,000 miles from its own base in Burma. In the west of Baluchistan, there is triangulation 700 and 800 miles, measured along the chains of triangulation, from the nearest Indian bases. The necessity for providing some check for all this outlying triangulation, in the shape of additional base lines, has given rise to the third period of base line operations upon which we are about to enter.

The measurement of new base lines reopens the question of standards and measuring apparatus, questions, in some respects not so easy of solution to-day as they were eighty years ago. The science of geodesy has developed enormously, even in the last forty years, in matters connected with both methods and instruments. The range of materials and design of apparatus from which selection has to be made is greater now than formerly and, at the same time, greater care has to be exercised in making the selection as the criteria of good work have become more exacting. The creation of an International Geodetic Association has so stimulated interest and endeavour in the various branches of geodesy that, though sympathy and co-operation have been thereby fostered, questions which formerly roused merely local discussion, now attract widespread attention and possibly draw a greater variety of opinions to be weighed and considered. Moreover, in India, we are now effecting our first junction with a foreign system of triangulation and it is probable that in the not distant future we shall form other connections both to east and west, and matters, at one time only affecting ourselves and admitting of a purely local solution, must now be considered with a wider outlook.

When we came to enquire into the standards of accuracy now established abroad, the necessity for the adoption of such standards, and the possibility of attaining the necessary precision with our existing apparatus, it became quite evident that the old base measuring apparatus would have to be discarded. The lowest degree of precision now required in the case of a geodetic base may be represented by $\frac{1}{2,500,000}$ and a failure to attain this standard would almost certainly lead to the subsequent geodetic operations being considered as of almost negligible value. The Colby apparatus is unable to attain this degree of precision. The "compensation" principle involved in its construction, though sound in theory, was impossible of perfect materialisation. Though the thermal expansion of the Colby unit had been reduced to a very small quantity, the effects of changes of temperature had not been eradicated entirely. There was difficulty in ascertaining the temperature of the components of the unit and it had to be assumed that the temperature was the same for each component. The changes of temperature during field opera-

tions were often considerable and the validity of this assumption was very doubtful.

Moreover, by reason of the complexity of the apparatus, the many adjustments that had to be made and the cumbrous nature of the pieces, the field practice was laborious and slow. Though, in its day, it was probable the best base measuring apparatus that had been devised, it must now give way to modern apparatus more portable and simple, yet, at the same time, permitting of the attainment of a higher degree of precision.

The apparatus generally in vogue to-day is designed, in one form or another, to apply Jäderin's system of measurement by wires hung in catenary. This type of apparatus, simple of construction, has been found to combine high accuracy with great portability, rapid progress and simplicity of field procedure. It is an apparatus of this nature that has been chosen to supplant the Colby bars.

But, entangled with the question of measuring apparatus was that of standard and unit. The accuracy of a measurement with any base line apparatus depends ultimately on the precision with which a certain length can be laid off with the basic standard. It had to be considered whether the precision attainable in an operation of this kind made with the present 10 ft. Bar A was of a degree that allowed full advantage to be reaped from the accuracy of measurement attained by the wires themselves; whether the quality of Bar A, as a standard, was sufficiently good to justify its being used in combination with the new apparatus. The enquiry into these matters made it evident that the precision attainable by the intermediary instrument, that is to say, the apparatus with which the actual measurements will be performed, is of a higher order than that inherent in the ultimate unit, the standard, and the retention of the latter could not be justified. It was necessary to declare as obsolete, not only the Colby bars, but also the standard Bar A of 1832. Both measuring apparatus and standard having to be replaced by modern types, the question arose whether this new equipment should be in terms of the foot or the metre. For the sake of simplicity in the operation of comparing base line apparatus with standard, all the equipment should be in terms of one and the same unit. For the purposes of geodesy, it was immaterial which unit was adopted, but, in consideration of the fact that the metre has been adopted now by practically all other geodetic bodies and for the sake of uniformity and the simplification of discussions dealing with work common to our own and to other systems of triangulation, in which the metre would most probably be the unit, it seemed desirable to abandon the foot and to adopt the metre.

The outcome of the decision to use the metre as the unit of future operations will be that the base line measurements of the third group

will be in terms of an abstract unit, whereas those of the second group were in terms of a concrete unit, Bar A.

The change of unit having been decided upon, new metre standards and base line apparatus were designed and constructed for the Survey of India. The equipment of standards consists of two 4-metre bars, one of invar, the other of nickel-steel (42 per cent. nickel) and two one-metre bars, one of invar and the other of pure nickel. They are all of the same type of section, a flanged H with the defining graduations cut on the upper surface of the cross bar. The 4-metre bars are graduated at every metre of their length, permitting of the determination of their linear value in terms of the one-metre bars.

If it be found that the use of a 4-metre bar is necessary in the field, the invar bar will in all probability be employed as the field standard while the Ni-steel will be maintained in Dehra Dun as a reference bar.

The most important desiderata in regard to a standard bar are a small thermal expansion and a great molecular stability. So far no metal or alloy has been found to combine in itself these two characteristics and it is to allow us to profit by the advantages conferred by both that two 1-metre bars have been provided. The invar bar, having a small thermal expansion, is little susceptible to changes due to temperature variations, while the nickel, though having a much larger coefficient of expansion, is more stable than the invar and less subject to molecular changes.

The length of each 1-metre bar has been determined in terms of the international metre.

Modern ideas of accuracy and the high degree of refinement attained in the construction of standards of length and observing instruments demand the taking of extreme precautions in the carrying out of bar comparisons. The chief difficulties to be contended with arise from changes and irregular distribution of temperature and, consequently, we find in modern comparators elaborate devices for ensuring steadiness and controllability in this respect. The old type of comparator existing at Dehra Dun, in which bars under comparison were but indifferently protected from temperature disturbances, will be replaced by apparatus permitting of the control of temperature to $0^{\circ}\cdot01$ C. and by which almost perfect uniformity of temperature distribution is secured.

The description of this new comparator is briefly as follows:—

On two masonry pillars, about 2 ft. high and 15 ft. apart, rests an iron box-girder, suitably protected from the effects of changes of temperature. Held in mountings capable of movement along the face of this girder, are two microscopes fitted with micrometer eye-pieces. The mountings can be clamped at any point on the girder, permitting of

the microscopes being placed at any distance apart from 0·5 metre to 4 metres. Below the girder, on rails laid transversely to its length, travels a platform carrying two tanks, each about 14 ft. long. These tanks are fitted to receive the bars under comparison. One tank will accommodate two bars, side by side, while the second will take only one, the bars being so placed as to be entirely immersed when the tanks are filled with water. In connection with the tanks are motor-driven pumps, capable of circulating the whole of the water in the tanks in 90 secs. In the circuit between the pump and the larger tank are an electric heater and a thermostat. By the operation of the former, the temperature of the water can be raised by rather more than 3° C. per hour. The thermostat is designed to automatically control the action of the heater so that, when the water has been brought to any required temperature, it can be steadily maintained within 0°·01 C. of this point. The temperature is indicated by several thermometers placed alongside the bars.

The small tank, having no heater, is designed to maintain the bar within it at a steady normal temperature. The larger tank provides the means of raising one or two bars to, and keeping them at, any temperature, for the time being abnormal.

By suitably selecting the positions of the microscopes on the girder and traversing the platform along the rails till a bar arrives in the correct position below the microscopes, micrometer observations can be made on the terminal graduations of the bar. If two bars are brought in succession under the microscopes, comparative readings can be made which will allow of the length of the one being deduced in terms of that of the other.

The provision of two tanks, in one of which the temperature may be regulated as desired, makes it possible to carry out a series of comparisons between two bars, one of which is maintained at a constant normal temperature for the whole duration of the observations, while the other is brought to a different temperature for each comparison of the series. Utilising the length of the bar under constant temperature as a datum for the time being, the length of the second bar at varied temperatures can be determined and the characteristics concerning its dilatation investigated.

By placing both bars under comparison in the same tank, determinations can be made of their relative lengths at any and the same temperature.

The comparator thus affords means of investigating the coefficients of expansion of the bars and of determining their lengths in terms of an adopted standard.

The base measuring apparatus consists of a set of 24-metre invar wires designed for use by Jäderin's system.

The determination of the length of a base necessitates the adjusting of the wire in successive positions which, starting from one end of the base, finally close on its further terminal. In each position of the wire the points defined by its limiting graduations are indicated by adjustible reference marks. The mark indicating the forward graduation of the wire in one position becomes the point to which the back graduation must be made to correspond in the next successive position. The determination of the true distances between these reference marks in each position constitutes the fundamental operation in the measurement of a base.

In each position, the wire is hung "in catenary," supported on two pulleys and strained by the action of weights.

The final length of the base is derived by combining the individual measurements given by each of the set of, generally, three wires.

To arrive at the length of the base, it is necessary to know the relation of the distance between the terminal graduations of the wire when hung in catenary, to the ultimate standard. To obtain this relation between our 24-metre wires and the international metre, a 24-metre comparator will be erected in Dehra Dun. The comparator consists of seven microscopes, securely mounted at intervals of 4 metres along a low masonry wall. Below the microscopes are laid rails along which travels a cradle designed to carry one of the 4-metre bars. By moving the cradle along the rails and thus bringing the 4-metre bar opposite each of the 4-metre intervals between microscopes, in succession, and by taking micrometer readings with each microscope of the bar graduation below it in the successive positions of the bar, it is possible to determine the distance separating the extreme microscopes in relation to the length of the 4-metre bar, which, by means of the 4-metre comparator, can be ascertained in terms of the international metre, as represented by the 1-metre standards.

Having determined the length between the extreme microscopes in metres, to get the length of each wire, all that remains to be done is to suspend each wire, in turn, below these microscopes and observe the positions of their defining graduations.

It will not be necessary to move this 24-metre comparator and a 4-metre bar into the field to the site of the base line to be measured. The procedure to be followed will be to standardise six wires at Dehra Dun, before departure for the field; on arrival at the base line, to lay out a 24-metre length between suitable marks on masonry pillars by means of three of the wires, which will, henceforth, not be used in the actual measurement of the base but be maintained as reference wires for the periodical checking of the distance between the marks on the pillars, the field comparator. The remaining three wires will be used to measure the base, their lengths being compared daily with the field comparator. On re-

turn from the field all six wires will again be standardised by means of the 24-metre comparator and thus a check obtained on any variations of length which may have occurred in the field.

PENDULUM OPERATIONS.

During the season 1912-13 measurements of gravity were made at 14 stations along a line extending from Bhopal to Khurja, near Bulandshahr, including Kalianpur, the station of origin of the Indian triangulation. The results are shown in the summary.

The three last columns in the summary need to be explained. The first, headed $(g_o - \gamma_o)$ shows the amounts by which gravity is in excess or defect on the assumption that surface masses have no effect thereon, the height of the station being alone allowed for in deriving g_o, the value of gravity at sea-level, from g the observed value. This method of reduction is sometimes known as the free air method.

The second $(g_o'' - \gamma_o)$ shows the excesses or defects on the assumption that all visible masses are of mean surface density and are entirely uncompensated. g_o'' is derived from g_o by the application of Bouguer's rule. Unless otherwise stated it is these residuals that are referred to in the subsequent discussion of results.

The third column $g - \gamma$ gives the residuals based on Hayford's hypothesis of isostasy or underground compensation of surface masses.

We have now completed a chain of stations along the meridian of 78° from Mussoorie (latitude 30° 28′) to Amraoti (latitude 20° 56′), a distance of about 650 miles, and it may be interesting briefly to review the results.

From Mussoorie to Gesupur (latitude 28° 33′) the defects of gravity decrease rapidly from ·11 to ·02 dynes. Between Gesupur and Khurja we find a rise to ·04 and from thence to Agra the negative residuals again decrease, becoming positive at the latter station. Between Agra and Bina we find 2 belts of deficient gravity or "valleys" separated by a positive area or "ridge." From Bina to Amraoti we have a succession of positive values with only two small negatives at Bhopal (·004) and Shahpur, latitude 22° 12′ (·005).

The existence of this area of excessive gravity, often called the hidden chain, was deduced by Colonel Burrard in 1901 from the evidence of the deflections of the plumb line. The pendulum has verified it, and this year the northern edge has been located between Kalianpur and Goona. This fact lends strong probability to the assumption that the deflection of the plumb line at Kalianpur is southerly.

It is interesting also to note that the positive areas at Sipri and Agra and the sudden change between Khurja and Gesupur are indicated

by the plumb line deflections in these localities. This seems to show that the variations of density which produce these abnormalities are situated near the surface.

Mention was made in last year's report of the investigation of the isostatic correction to gravity results. This has now been extended and about 40 stations have been dealt with. Generally speaking the effect of this new method of allowing for the effects of the topography is to decrease negative residuals and increase positive ones at all stations except those near the sea coast. At coast stations positive residuals are decreased. At stations which are distant both from the sea and from mountains the change amounts to from 0·03 to 0·05, but near the sea and near mountains much greater changes are produced. The following table shows a few of these changes:—

Station.	Locality.	$g_0'' - \gamma_0$ Bouguer.	$g - \gamma$ Hayford.	Change.
Mussoorie . . .	On the edge of the Himalaya .	−·110	+·075	+·185
Dehra Dun . .	7 miles from Himalaya . .	−·126	+·029	+·155
Nojli . . .	65 „ „ „ . .	−·095	−·007	+·088
Gesupur . . .	130 „ „ „ . .	−·020	+·029	+·049
Chatra . . .	180 „ „ „ and coast	+·009	+ 030	+·021
Madras . . .	On coast	+·014	−·025	−·039

As will be seen from the summary of results and the table above the great majority of the Hayford residuals are positive. This merely means that another formula for computing γ_0, the normal value of gravity at sea-level, will have to be used. The point to be noted is that the Bouguer residuals are as a rule negative near hills and positive near the coast and that the new method will reduce the residuals in each case. Local anomalies, such as have been found during the last season, will, however, not be affected.

Summary of results, 1912-13.

Station.	Latitude.	Longitude.	Height above M. S. L.	Observed value of g.	Correction for: Height.	Correction for: Mass (Bouguer).	Correction for: Mass (Hayford).	$g_{\circ}=g$ corrected for height only.	$g_{\circ}''=g$ corrected for height and mass (Bouguer).	$\gamma_{\circ}$	$g_{\circ}-\gamma_{\circ}$ (Free air).	$g_{\circ}''-\gamma_{\circ}$ (Bouguer).	$g-\gamma$ (Hayford).
	° ′ ″	° ′ ″	Feet.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Bhopal	23 15 58	77 25 00	1,630	978·711	+0·152	−0·057	−·007	978·863	978·806	978·810	+0·053	−0·004	+·046
Balianpur	24 07 11	77 39 17	1,763	978·717	+0·164	−0·062	−·011	978·941	978·879	978·867	+0·074	+0·012	+·063
Kina	24 10 41	78 11 46	1,355	978·795	+0·126	−0·047	±·000	978·921	978·874	978·871	+0·050	+0·003	+·050
Goona	24 38 48	77 19 13	1,569	978·807	+0·146	−0·055	−·007	978·953	978·898	978·903	+0·050	−0·005	+·043
Lalitpur	24 41 29	78 21 26	1,199	978·814	+0·112	−0·042	+·003	978·926	978·884	978·906	+0·020	−0·022	+·023
Sipri	25 25 52	77 39 25	1,533	978·876	+0·143	−0·054	−·009	979·019	978·965	978·958	+0·061	+0·007	+·052
Jhansi	25 27 02	78 33 43	858	978·910	+0·080	−0·030	+·007	978·990	978·960	978·959	+0·031	+0·001	+·038
Gwalior	26 13 57	78 12 49	658	978·958	+0·061	−0·023	+·012	979·019	978·996	979·015	+0·004	−0·019	+·016
Dholpur	26 42 01	77 54 47	577	978·999	+0·054	−0·020	+·015	979·053	979·033	979·048	+0·005	−0·015	+·020
Agra	27 10 20	78 01 07	535	979·056	+0·050	−0·019	+·018	979·106	979·087	979·083	+0·023	+0·004	+·041
Muttra	27 28 25	77 41 48	562	979·072	+0·052	−0·020	+·019	979·124	979·104	979·105	+0·019	−0·001	+·038
Hathras	27 36 52	78 03 22	587	979·075	+0·055	−0·021	+·020	979·130	979·109	979·116	+0·014	−0·007	+·034
Aligarh	27 53 32	78 00 31	612	979·075	+0·057	−0·021	+·021	979·132	979·111	979·137	−0·005	−0·026	+·016
Khurja	28 14 19	77 51 53	649	979·083	+0·061	−0·023	+·024	979·143	979·120	979·163	−0·020	−0·043	+·004

$\gamma_{\circ}=978·00\ (1+0·00531\ \mathrm{Sin}^2\ \phi)$

LEVELLING OPERATIONS.

During the year 1912-13, the following lines of precise levels were run:—

(a) In Kashmir.

Kohala to Srinagar.
Srinagar to Islamabad.
Islamabad to Phalgam.
Srinagar up the Sindh Valley.
Srinagar towards Bandipur.
Srinagar towards Shopian.

(b) In the Punjab.

Multan to Mahiwala.
Ambala to Jagadhri.
Delhi to Hodal.
Murree to Kohala.

(c) In the United Provinces.

Jagadhri to Meerut.
Meerut to Delhi.
Hodal to Muttra.

(d) In Bengal.

Comilla to Chittagong.

Brahmanbaria *viâ* Ashuganj, Bhairab, Dacca and Goalundo to Faridpur; crossing the Meghna, Lakhya, Dhaleshri and Padma rivers, distances across being, respectively, 65, 35, 52 and 109 chains of 66 feet.

To cross the first three rivers, the "target" method was adopted, and for the last, vertical angles were observed.

The line Dacca to Mymensingh had been included in the programme, but it was not found possible to complete it. It will be completed in 1913-14.

(e) In Burma.

Henzada to Bassein along the left bank of the Ngawun river.
Pegu to Mokpalin.

In the programme it had been intended to carry this line on to Magwe which would have completed the first circuit in Burma, but owing to stress of weather, work was stopped at Taungdwingyi, some 60 miles distant from Magwe. It will be finished in 1913-14.

The line Thazi to Taunggyi had also been included in the programme, but it was not found possible to take it up. It is now intended to complete it in 1913-14.

In addition to the above lines of precise levelling, about 41 miles of single levelling were carried out at Darjeeling, in the cantonments of Takdah and Lebong and in the Happy Valley landslip-area, as an aid for the surveying of contours for large scale maps of these places.

TIDAL OPERATIONS.

During the year tidal registrations by automatic tide-gauges have been continued at the following ports, with satisfactory results:—

Aden, Karachi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein, and Port Blair.

BOTANY.

I.—BOTANICAL SURVEY.

BY

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Eastern India.—The work of the Royal Botanic Garden, Sibpur, has become so closely associated with the work of the Botanical Survey that an account of the progress made by officers in their former capacity must find a certain degree of repetition in the Botanical Survey Report. During the year under review, the Director in his capacity as Superintendent of the garden has continued the work of cataloguing initiated by him in 1909 and progress has also been made with the preparation of the systematic list which is intended to be supplementary to the numerical and in which the plants will be arranged according to their Natural system of classification. The numerical list itself is far from complete. In the list as it stands there still remain many blanks to fill up and the addition of new material to the garden will involve additional numbering while the extraction of what dies or has for other reasons to be removed naturally renders such a list useful only within a limited period. The systematic list which it is intended to prepare should serve the useful purpose of letting one know at a glance what the garden actually possesses and the garden numbers which will also be inserted will allow of reference to the plants themselves, without the extra trouble of looking over pages of the numerical list before the particular plant wanted is recognised. The work when completed should form a most useful aid in systematic work, for if doubt is entertained regarding the identity of any species sent in for examination a ready reference will be had to the living plant itself as well as to the dried herbarium material. In July 1912, Volume V, No. 4 of the Records of the Survey appeared and the list as stated in last year's report now totals some 13,400 numbers. As regards the indentification of critical species and the subsequent filling in of blanks a large number of plants of doubtful standing which had accumulated and awaited a favourable opportunity for study was taken by Major Gage to Kew where it is hoped sufficient material will be available to allow of comparison and systematic classification. Signor Beccari continues to investigate the garden palms which are at present most in need of study and several species formerly of

doubtful standing have been identified. Lately a large consignment of these has been forwarded for favour of report, but it is not always possible with palms to send at one time the complete material which a critical study requires as many of the more interesting flower and fruit at irregular intervals. Already a list of useful identifications has been forwarded by Signor Beccari and his requests for complete material are being complied with as the more critical species come to maturity. Outside Eastern and Southern India the limited staff of the Botanical Survey has been able to accomplish no field work, but various collectors who have been engaged in other directions have sent their material for report and record. In January and February of 1913 Major Gage toured in parts of Burma and was thus able personally to supplement the excellent work done by Forest and other Government officers and private individuals on whom the Survey has had to depend so much for material from this province. The collections come mostly from the higher elevations 2,000—4,000 feet. They number some hundreds and were got to the Herbarium in excellent condition. These have been sent to Kew but were first roughly classified before despatch. Time has not yet permitted of their being worked up, but doubtless interesting records will accrue from their examination. The parts explored lie in North Arracan and the Toungoo district of Burma. In North Arracan Major Gage studied the vegetation of the district East of Paletwa which lies between the Kaladan and Mee Rivers and spent a good deal of his time on Kyaukpaudaung Peak. In Lower Burma he botanised in the locality of Thandaung, North-East of Toungoo. In both districts the idea followed was that of intensive collection from a limited area rather than extensive work covering a wider field. During the year Volume IV, No. 7 of the Records of the Botanical Survey has appeared. This number is devoted to a record of the exploration undertaken by Mr. W. W. Smith, late Curator of the Herbarium, in 1910 and treats of the Alpine and Sub-Alpine vegetation of South-East Sikkim. In all some 925 plants are recorded, an interesting general account of the flora is included and the following new species are described in the list:—*Paroxygraphis sikkimensis*, *Draba cholaensis*, *Arenaria Balfouriana*, *Potentilla microphylla* Don., var. *pusilla*, *Saxifraga Gageana*, *Saxifraga pluviarum*, *Trachydium affine*, *Leycesteria Belliana*, *Senecio biligulatus*, *Senecio Kingianus*, *Senecio Lagotis*, *Senecio Chola*, *Saussurea nimborum*, *Saussurea Laneana*, *Gentiana pluviarum*, *Swertia ramosa*, *Swertia Burkilliana*, *Pedicularis siphonantha* Don., var. *prostrata* Bonati, *Pedicularis sikkimensis* Bonati. Two species of *Juncus* may prove to be undescribed species but they require fuller investigation and comparison with ampler material of the genus. In Burma collections were made by Mr. J. H. Lace, late Chief Conservator of Forests, and Captain Abbey and over 200 sheets have been forwarded from this source to the Herbarium for report as well as a small collection from Mr. C. G. Rogers. Among those sent by Mr. Lace, were

several which would have formed useful additions to our Burma material and some of these Mr. Lace has kindly allowed the Herbarium to retain. Mr. Lace has also found it possible during the year to complete his materials for a "List of trees, shrubs and principal climbers recorded from Burma" and the work has now been published. The arrangement follows that of the Flora of British India except that there is an alphabetical arrangement of the species under each genus and Burmese, Kachin, Karen and Shan names are supplied. The work should prove an excellent reference list to students of the flora who can already claim a certain acquaintance with systematic work. The flora of Burma has also received the marked attention of Mr. C. G. Rogers, Conservator of Forests, who continues to submit from time to time small collections for comparison with the Sibpur material. During the year a collection of between forty and fifty sheets has been received from this source and the more useful we have been allowed to retain for the Burma local Herbarium. Botanical exploration in Bhutan has not always been an easy matter in the past, not on account of the area itself offering insuperable difficulties to such work but on account of difficulties in obtaining permission to enter the territories. The acquisition of some 200 specimens collected in this comparatively unworked region by Mr. Jacob, who has been deputed there as Forest officer, is therefore all the more worthy of note. Such a collection even in conjunction with what has already been done on the flora gives but a very superficial knowledge of its wealth, but such forms as *Eleagnus pyriformis* Hook. f. *Argyreia Hookeri* C. B. C., *Schima Wallichii* Choisy, *Anisochilus polystachyus* Bth., *Strobilanthes pentstemonoides*, T. Anders. *Stephania elegans* Hf. & T., *Priotropis cytisoides* W. & A., *Ajuga macrosperma* Thw., *Lysionotus serratus* Don., *Strobilanthes coloratus*, T. And., var. *crinita*, *Daphniphyllum himalayense* Muell. *Photinia integrifolia* Lindl. *Heracleum nubigenum*, C. B. C. *Clematis nepalensis* DC., *Holmskioldia sanguinea* Retz., *Dipsacus inermis* Hf. & T., *Bridelia sikkimensis* Gehrm., *Senecio Bhot* C. B. C., *Natsiatum herpeticum* Ham., and *Wendlandia pendula* DC., at once mark the district as typically East Himalayan in its flora. The last named species is recorded for the first time from Bhutan. Other collections from Northern India include some 500 sheets from Mr. Cave, Curator of the Lloyd Botanic Garden, Darjeeling, and a collection similar in numbers from Mr. B. J. Gould, British Trade Agent in Gyantse. The last named collection though somewhat incomplete as regards the individual specimens nevertheless afforded a number of useful additions. This is only to be expected when one considers the limited amount of biological exploration that has been possible in Tibet. Among those identified there are present *Scutellaria Kingiana* Prain, *Triglochin martimum*, L., *Anemone trullifolia* Hk. f. & T., var. *linearis* P. Bruhl. *Meconopsis paniculata*, Prain., *Braya tibetica* Hk. f. & T., besides many others of interest which have filled

gaps in the general and local Herbaria. A very valuable set of Wight's plants numbering upwards of 7,000 sheets have been presented by the Regius Keeper of the Botanic Gardens, Edinburgh. These have been drawn from all parts of the Peninsula and the co-types which are included add greatly to the value of the set as a whole.

It is not always possible to make analytical work in the Herbarium keep pace with field work but several collections made prior to the year under review have undergone examination. In 1911-12 Mr. Meebold toured in Mergui, Thaton and Salween in Lower Burma and his plants which have now been worked out are useful as showing the occurrence of well marked endemic forms of typical Malayan species and the relative scarcity of Upper Burma species. This is exemplified by the following few species which find a place in the list *Ixora opaca* R. Br., *Glochidion insulare* Hook. f., *Ervatamia cylindrocarpa* King and Gamble, *Embelia nagushia* Don. A new species *Cleistanthus Meeboldii* Jabl. has also been recorded as well as *Cleistanthus myrianthus* and *Cleistanthus Helferi* Hk. f. A small collection of plants made by the same Botanist at Mungpoo in the beginning of 1912 has also been worked up and several gaps in the local Sikkim Herbarium filled though the list shows no new records. During the year Captain Toppin's Kampti Long Mission collections made in 1911-12 have been named with the exception of the genera Quercus and Begonia. A large number of species that were formely supposed to be endemic only in Upper Assam is represented in this collection while a few Chinese plants are also to be found. The families Leguminosæ, Rubiaceæ and Acanthaceæ are well represented. Considering the area dealt with in the collection it would seem that there is quite an appreciable endemic element and a number of new species seems assured. The whole collection has gone to Kew for revision and a report will probably be given on it at a later date. In 1911 Mr. I. H. Burkill and Mr. S. C. Banerji undertook a tour in the Khasia and Jaintia Hills which resulted in the acquisition of nearly 800 sheets. These have now been studied and have resulted in the following new records for the district *Spiræa micrantha* Hk. f., *Rosa Leschenaultiana* W. and A., *Webera corymbosa* Willd. *Leptodermis lanceolata* Wall. *Taxotrophis zeylanica* Thw. Among those examined was also a Sagittaria sagittifolia L. with the leaves elliptic instead of, as is usually the case, hastate, a form which is said to be of rare occurrence.

Mr. Gamble has continued his work on the flora of the Malayan Peninsula and during the year an account of the families *Myristicaceæ*, *Monimiaceæ*, *Thymelaeaceæ*, *Elaeagnanceæ* and *Santalaceæ*, has appeared in the *Journal of the Asiatic Society of Bengal*. Five new species are described of which *Santalaceæ* has four and *Thymelaeaceæ* one.

Mr. W. G. Craib has published his second list of Siamese plants with descriptions of new species. The list comprises the monocotyledons and

the following new species are dealt with. *Globba Kerrii* Craib, *Globba Nisbetiana* Craib, *Globba purpurascens* Craib, *Globba xantholeuca* Craib, *Globba Yeatsiana* Craib, *Curcuma ecomata* Craib, *Amomum siamense* Craib, *Zingiber Bradleyanum* Craib, *Zingiber Kerrii* Craib, *Zingiber Smilesianum* Craib, *Halopegia brachystachys* Craib, *Tacca Garrettii* Craib, *Stemona aphylla* Craib, *Stemona Kerrii* Craib, *Smilax Hemsleyana* Craib, *Disporopsis longifolia* Craib, *Ophoipogon brevipes* Craib, *Ophiopogon gracilipes* Craib, *Chlorophytum intermedium* Craib, *Chlorophytum simplex* Craib, *Aneilema discretum* Craib, *Aneilema siamense* Craib, *Pandanus distans* Craib, *Pandanus similis* Craib, *Arisaema hypoglaucum* Craib, *Arisaema Kerrii* Craib, *Arisaema sootepense Craib*, *Amorphophallus macrorhizus* Craib, *Mariscus Clarkei* Turrill. A new cycad *Cycus immersa* Craib, is also described. The same author has also described *Flemingia Lacei* Craib, *Flemingia augusta* Craib, *Agapetes Lacei* Craib, *Agapetes oblonga* Craib, *Wightia Aplinii* Craib, all new species from Burma. *Primula Wattii* King ex Watt, a species originally met with in Sikkim has also been described by Mr. Craib in the Botanical Magazine No. 1507, where a figure of the plant is also to be found. Mr. Gamble has described the new species *Loranthus Robertsonii* Gamble, *Henslowia Collettii* Gamble, *Henslowia shanensis* Gamble from Burma, *Erytranthe papillosa* Gamble, *Erytranthe Barnesii* Gamble, *Erytranthe Robinsonii* Gamble, *Erytranthe Wrayii* Gamble, *Viscum Wrayii* King ex Gamble, *Viscum flexuosum* King ex Gamble from the Malay Peninsula and *Viscum costatum* Gamble from the Darjeeling district.

Sir David Prain has described three new species of *Helicia* from the Malay Peninsula *Helicia Kingiana*, Prain, *Helicia rufescens* Prain and *Helicia velutina* Prain. Mr. N. E. Brown has contributed a description of *Gentiana minuta* N.E. Brown from the Tunkra Pass in the Himalaya and Mr. S. T. Dunn of *Crotalaria Meeboldii* Dunn and *Polygonum palmatum* Dunn, both from Assam. Other noteworthy species described include a *Cornus* by Dr. Stapf and a new species *Berberis Parkiana* Schneider from the Western Himalaya.

The flora of Indo-China continues to receive the attention of M. Gagnepain and several fasciculi of his Flore Generale de l'Indo-Chine have been published during the year. The treatment of the subject is exhaustive, the last fasciculus to hand comprising 100 pages devoted exclusively to the *Leguminosæ*. Roxburgh's Hortus Bengalensis published nearly a century ago and his catalogue of described plants which had at that time not yet been introduced into the garden have been reviewed by C. B. Robinson, an American botanist, who supplies some interesting observations on the nomenclature used.

Western India.—Mr. D. Hooper has contributed 600 sheets to the Herbarium, some of these having come from the Western side of the

peninsula. Apart from this contribution little has been done by the Botanical Survey staff in the way of field work on the west. A review of the publications of the year, however, will show that botanical work is being well supported there. The Orchids of the Bombay presidency are receiving the attention of Mr. G. A. Gammie who is adding from time to time in the *Journal of the Bombay Natural History Society* to our knowledge of the family while Father Blatter's exhaustive account of the Palms of British India and Ceylon also being continued is a work of which Indian Botanists may well be proud. The same author has now completed his flora of Aden which will appear in parts of the *Records of the Botanical Survey of India* at an early date. The flora gives a history of the Botanical exploration of Aden, a description of the physical aspects, a full general account of the vegetation wild and cultivated, a complete synopsis of the natural orders and descriptions of all the species amounting to 250 nearly thrice as many as described by Anderson 50 years ago. Keys are supplied and also an exhaustive bibliography.

Mr. R. K. Bhide has described two more species of *Gramineæ* from Bombay.

Northern India.—Colonel C. J. Bamber has added in the *Journal of the Bombay Natural History Society* several additions to his plants of the Punjab, North-West Frontier Province and Kashmir, while Herr Schneider has described a new *Berberis* from the Western Himalaya and cites the area as possessing many new and curiously localised species of the genus. Regarding this interesting addition—*Berberis Parkeriana* collected by R. N. Parker in Hazara—he remarks as follows:—

"Ich erhielt diese Art von Herrn R. N. Parker aus Lahore, welcher sie im Hazaradistrikt (westl. Himalaya) sammelte, und zwar die Blutenzweige in Bagnolar Reserve, 2600 m, April 1910, und die Fruchttriebe in Abbottabad, 1800 m, Juli 1910. Sie gehort in die Sektion Tinctoriæ C. S. (Eutinctoriæ), wo sie aber von allen bisher bekannten Arten durch die lanzettlichen, unterseits nicht papillosen Blatter abweicht. In der Blattform ahnelt sie sehr B. lycium, diese hat aber unterseits weisspapillose Blatter und langere Trauben. Herr Parker bemerkt zu seinen Pflanzen; B. calliobotrys? Die Fruchte erinnern auch an die B. calliobotrys Aitch., allein diese Art hat kleinere Blatter, kahle, braunrote junge Triebe und weicht auch in den kleineren Blutenstanden und sonst ab."

Southern India.—Apart from the publication of botanical work concerned with this part of the peninsula a considerable advance has been made with the collection of materials for the survey. Southern India and Burma will require in the future the increased attention of the Botanical Survey staff for large areas, the knowledge of the flora of which is comparatively scanty, remain for exploration. During the year the Director was able to depute two of the staff Mr. Hooper and Mr. Ramaswami to Tinnevelly and a survey of two taluks Ambasamudram

and Nanguneri in the district was undertaken. Copious notes were made and the expedition resulted in the acquisition of about 700 sheets. Time has not permitted of the whole collection being worked out, but so far as it has been studied it would seem that the family *Leguminoseæ* with fifty-two species is the most widely represented. *Rubiaceæ* comes next with thirty-seven species; *Compositæ* has thirty-two, *Convolvulaceæ*, *Acanthaceæ*, *Labiatæ* and *Filices* twenty-four each, *Verbenaceæ* has eighteen and *Euphorbiaceæ* and *Urticaceæ* thirteen each. The remaining families contain fewer than ten species each. The flora of the plains as might be expected shows a striking similarity to that of the adjacent island of Ceylon, while the hills possess a flora comparable with that found on the slopes of the Nilgiris. Even in the hills, however, there are local variations of the flora due chiefly to local variations in rainfall. As the survey of the district proceeds full reports will appear of its vegetation, but the following few endemic species may now be mentioned as forming part of the collection:—*Leptonychia moacurroides* Bedd., *Homalium travancoricum* Bedd., *Hedyotis purpurascens* Bedd., *Vernonia travancorica* Hook. f., *Blepharispermum petiolare* DC., *Symplocos acuminata* Bedd., *Diotacanthus grandis* Benth., *Mallotus stenanthus* Muell. and *Elettaria cardamomum* Maton. the last named found wild only in this part of India.

Mr. C. E. C. Fischer, Deputy Conservator of Forests, continues to be one of the mainstays of botanical work in this part of the peninsula and has this year contributed over 600 sheets from Coimbatore, Anaimalai and Palni Hills. Numerous interesting records accrue, including some examples of new species recently described by Mr. W. W. Smith from Southern India. During the year the survey has been fortunate in enlisting the services of the Reverend St. Münch, S.J., and the Reverend A. Sauliere, S.J., both of the S. H. College, Shembaganur, and both of whom have ungrudgingly contributed large collections from the Madura district and done much to help on the survey in the Peninsula. Over 700 sheets have been forwarded for identification from this quarter, but the limited staff of the Herbarium has not been able to cope with all demands for floral analyses, and a considerable number of the Madura plants still await examination. From what has been accomplished, however, it becomes evident that the typical Deccan element is well represented in the district explored. A short extract from the report of the Government Botanist, Madras, on Systematic Botany is of interest in connection with South Indian Botany. "All the specimens collected by Dr. Barber, except imperfect and unidentifiable sheets have been identified and incorporated with the main collection. Besides these 887 sheets of specimens of plants collected by Dr. Bourne on the Pulney hills and 691 sheets of Mr. Gamble's collection were also incorporated. The Grewias sent to Kew for identification were returned. In this lot eight

species are new to science; *i.e.*, *Grewia Wightiana*, *G. Griffithiana*, *G. Gamblei*, *G. Lawsoniana*, *G. Wattiana*, *G. Barberi*, *G. Optiva*, *G. pandaica*. A further lot of Grewias was again sent for identification. About 50 sheets of duplicate specimens of Grewias were sent to Mrs. Bourne. During the year 1,633 sheets were named and names were written on 2,404 sheets. All the original pencil drawings of Wight and Beddome's published works received from Ootacamund have been sorted and mounted in albums. About 150 plants were identified for various correspondents."

General Systematic.—M. G. Dismier has done much to clear up the confusion which existed in regard to Indian and other Asiatic species of *Philonotis* and has set forth his views based on examination of material from the more important European collections, on the characters which separate *Philonotis falcata* (Hook.) Brid. and *Philonotis Turneriana* (Schw.) Mitt. from nearly allied species. He has been able to include in the synonymy list numerous species which rightly have only varietal rank and to furnish critical remarks concerning the species he considers synonymous. A treatment of their geographical distribution adds to the value of the discussion. In *Philonotis falcata* (Hook) Brid. he has been able to include some twelve and in *Philonotis Turneria* (Schw.) Mitt. some four species. As regards his views on the distinguishing characteristics of these the following may be quoted from the Bulletin de la Société Botanique de France. "Toutefois, il me parait nécessaire, au préalable, d'indiquer de quelle manière je comprends les *Philonotis falcata* et *Philonotis Turneriana*. En général, chez ces deux espèces, les feuilles sont ovales-lancéolées, acuminées et disposées en rangées spiralées. Quelques spécimens cependant ne paraissent pas, á première vue, offrir cette disposition caractéristique; mais, en les examinant avec soin, on finit toujours par trouver quelques tiges ou portions de tiges à feuilles sériées. J'insiste sur cette disposition spéciale car elle a pour moi une valeur de premier ordre; elle ne m'a jamais fait défaut dans tous les échantillons—et ils sont nombreux—que j'ai étudiés. J'ajouterai que ces feuilles, chez le *Philonotis falcata* de même que chez le *Philonotis Turneriana*, sont carénées, concaves, â bords plats, et â dents simples sur tout le contour; vues au microscope sous le couvre-objet, elles sont, par suite de leur concavité, les unes condupliquées, les autres fendues sur une assez grande longueur. Quant aux cellules elles sont carrées ou brièvément rectangulaires et papilleuses à leur partie supérieure; de plus, chez le *Philonotis falcata* la nervure est de largeur moyenne, tantôt percurrente, tantôt plus ou moins excurrente, tandis que chez le *Philonotis Turneriana*, qui n'est, à mon avis, qu'une sous-espece, elle est toujours longuement piliforme."

Since last report was written several volumes of Das Pflanzenreich have appeared and the following families are discussed—*Geraniaceæ*,

Goodeniaceæ, Brunoniaceæ, Araceæ, Cannaceæ, Euphorbiaceæ. The value of this work which is the result of years of study by some of the best Botanists in Europe can scarcely be overestimated. It comprises the most noteworthy species known all the world over and reference to the work will show the richness of India in species in comparison with other countries. Several revisions of genera of interest to Indian botanists have appeared during the year. M. R. Benvist has dealt with the structure and classification of the *Acanthaceæ* of the tribe *Barleria*, the genus *Cousinia* has been dealt with by Bornmüller, the *Gentianaceæ* of Indo-China by Dop. A revision of *Saxifraga* section *Hirculus* and new species of other sections has formed the subject of investigation by Engler and Irmscher who have described amongst others the following new Indian species:—*Saxifraga Kinchinjungæ, S. sikkimensis, S. Kingiana* (S. Gageana) *S. eglandulosa, S. chumbiensis, S. subspathulata, S. elliptica* varieties of *S. diversifolia, S. pseudo-hirculus, S. punctulata, S. flagellarioides, S. Andersonii* all from Eastern Himalaya and Calcutta garden collections also *S. Meeboldii* from N. W. Himalaya.

Mr. Gagnepain has published a further fasciculus of his Flora Generale de l'Indo-Chine incorporating his work on the *Leguminosæ* of that region.

Mr. S. T. Dunn who has had much Indian material at his disposal has revised the genus *Millettia* and the following new Indian species and varities are recorded:—*Millettia Griffithii* Dunn, *M. eriocalyx* Dunn, *M. Pulchra* Kurz., var *microphylla, M. trifoliata* Dunn, *M. podocarpa* Dunn, *M. Prainii* Dunn, *M. Cubitti* Dunn. The bibliographical list will show the chief botanical works of a general kind having reference to Indian botany, which have come under notice.

Anatomical and Physiological.—The structure of the female Strobilus of *Gnetum Gnemon* has been dealt with by Mr. E. M. Berridge. The first stages of the development of *Terminalia Catappa L.* has found the subject of a study by M. Colani. Herr Hanausek has studied the pericarp and pericarp secretion in the genus *Carthamus*, Mr. Hector, Economic Botanist to the Government of Bengal, has experimented on the pollination and cross fertilisation of the common rice plant *Oryza sativa* Linn. Mr. E. L. Stephens has been engaged on the anatomy, structure and development of *Striga lutea* Lour. and numerous other Botanists have added materially to our anatomical and physiological knowledge by studies conducted with Indian material or adduced results which can be made applicable to Indian Botany. The Royal Botanic Garden has been instrumental in collecting and forwarding material of *Gnetum* at various stages of development to Professor Pearson who is engaged in a study of the development of the ovule and the results of whose observation are awaited with interest. Further references on anatomical and physiological subjects may be seen in the bibliographical list appended.

A list of papers containing references to the Botany of India published mostly during 1912-13.

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BAMBER, C. J. . Plants of the Punjab, X. (*Journ. Bomb. Nat. Hist. Soc., xxi, No. 3, 1912, p. 1022-1060.*)

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BEAUVERD, G. . Contribution à l'étude des composées asiatiques. (*Bull. Soc. Bot. Genève, 2e Série, i.p. 364-388.*)

BENVIST, R. . . Recherches sur la structure et la classification des Acanthacées de la tribu des Barlériées. (*Lille, 1912, p. 108.*)

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II.—ECONOMIC BOTANY.

Part I.—AGRICULTURAL BOTANY.

BY

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Considering the number of workers in the field, the output of research in Agricultural Botany is, as usual, small. There are, however, very few, especially in the Provinces, who have any time to deal adequately with this important subject. With hardly an exception, the Provincial Agricultural Botanists report that almost the whole of their time is taken up in teaching. Preparing courses of lectures in a country where the very alphabet, in the shape of species, is new, is no light matter, and it must take some time before the new officers have much to say on the applied science, but there are signs that a change is taking place and that more time will be available for research than heretofore. In Madras the much-needed change has taken place during the year and teaching and research have been definitely separated under whole-time officers. In the other Provinces the teaching courses are rapidly becoming stereotyped and more attention is being paid to the collection and study of groups of the cultivated plants. A considerable amount of time is being devoted to the economic survey of the crops grown in India, wheat, sugarcane, cotton, paddy, tobacco, pulses, oil seeds, capsicums, peppers and mangoes having received special attention during the year. Added to this general survey, pure line cultures have been instituted in most of those mentioned.

One of the most striking characters in Indian crops, grown for centuries under the same conditions, is the enormous extent of admixture of varieties in almost every field, and perhaps no part of the world offers a finer field for investigation to the Economic Botanist. In many cases, mere separation of the various types by pure line culture has led to great agricultural progress, while the field opening up for the creation of new varieties along Mendelian lines is a vast one and full of promise, it having been abundantly demonstrated in every crop investigated that there is a large margin within which improvements may be effected. This is perhaps the most promising line of work before the Agricultural Department at the present moment, and it is sincerely to be hoped that

the example of Madras noted above may be followed elsewhere and that the excellent work now being done by the purely agricultural members of the service may be stimulated and encouraged by placing full-time officers in charge of breeding work, the teaching in the Colleges being provided for by the creation of a special teaching staff. Attention is strongly drawn to the fact which has been emphasised by the work of the Howards on wheat, that breeding work is more difficult than was at first anticipated, and that improvement of crops, by the creation of new varieties combining the useful properties of several parents, can no longer be approached lightly. Meanwhile, the mere selection of varieties is leading to important results and it is becoming increasingly certain that, unless full time is available for breeding work and great care exercised in its prosecution, the results are likely to be disappropriating.

An attempt will be made in the present report to deal as widely as possible with the crops being studied and thus to indicate the directions in which future expansion may be looked for. The important work on wheat and cotton, which has filled most of the previous reports, will be more briefly summarised.

Paddy.—There are various indications that this, the most important food crop in the tropics, is at length about to receive the attention it deserves.

Hector has made a survey of the chief Aman transplanted paddies of Lower Bengal. In the 150 varieties which he has isolated and grown in pure lines, he has found that the morphological and cultural characters are transmitted, and no case of crossing has occurred in his pure line plots. The correlation between the varietal and field characters and the composition of the grain is being studied by him in conjunction with the Agricultural Chemist. He has, further, made a study of paddy pollination, and disagrees with Knuth as to the normal dehiscence of the anthers. He finds that paddy in Bengal behaves in the manner described by Akemine in Japan and van der Stok in Java. According to these observers, self-fertilisation is the rule, while crossing occasionally takes place, so that it is necessary to be on the guard against this in breeding work. According to Hector, arrangements are made at the moment of the opening of the flower for immediate anthesis, so that the stigma, still enclosed in the flower, is copiously dusted with pollen from the same flower. In his comparison of the anthesis and flower-opening of the Aman and Aus paddies, he finds differences which he considers to be due to varying degrees of moisture and temperature at these two periods of the year. A little pollen being left in the anthers after the opening of the flower, cross-pollination is possible. Hector has not apparently observed this, but he infers it from the observed characters in the offspring which, when selfed, reproduced the parental peculiarities in Mendelian proportions. He concludes, however, that cross-pollination in

paddy is strictly limited, and only takes place between plants growing in close proximity.

Hilson has made a series of observations on the pollination of paddy in Madras and has commenced a study of the varietal characters which appear to be inherited. Graham in the Central Provinces has completed the survey of the paddies grown, the material accumulated being preserved in 1,345 herbarium sheets. He has isolated 81 varieties and grown them in pure line cultures, and certain of the better kinds have been handed over to the farms for propagation and distribution. Sawyer and Thompstone have done similar work in Burma, pure line cultures having been grown for a couple of years, and a great demand has arisen at the Mandalay farm for certain better kinds.

The purely agricultural work continues. Paddy transplantation in the Central Provinces now extends to 16,000 acres, with an average increase in yield of one-third of the crop, and great hopes are entertained of a further expansion of this work. In the same way the campaign in single-seedling planting has been vigorously continued in Madras and the method is being tested in various other Provinces. It is notable that both in the Central Provinces and in Madras it is claimed that these simple improvements in the method of planting will, in time, amply cover the total cost of their respective Agricultural Departments in increased production. The distribution of improved or pure seed continues to increase, between 30,000 and 40,000 lbs. having been sold during the year in Madras alone.

Wheat.—The excellent work done by the Howards on this important crop continues to yield valuable results, and several papers have been published during the year, while their efforts at improving the Indian wheats have been ably seconded in the various Provinces interested in this crop, especially by Leake in the United Provinces and Clouston in the Central Provinces. It is not proposed to deal with these papers at length in the present report, partly because some attention was drawn to them last year while in the press, but chiefly because of the absence of the authors in England and the extreme importance and intricacy of the subject.

Considerable progress has been made in the study of the inheritance of morphological characters. It has been demonstrated, in confirmation and extension of the work of Nillson-Ehle at Slavöf, that apparently simple characters, such as the red colour of the grain, the hairs in the chaff in felted wheats, bearding, shattering of the ear, and so forth, are really complex and dependent on several factors. It has, further, been demonstrated that the influence of the environment cannot be ignored in these studies, as it is found sometimes to clock inherited characters of minor importance, thus rendering the isolation of new kinds more complicated still. It is not to be supposed that wheat is peculiar in this respect

among Indian crops, and this makes it all the more necessary that workers in this branch of agricultural improvement should be able to devote their undivided attention to it and be freed from all other claims upon their time. As the authors point out "plant breeding has been started at stations as an addition to an already over-loaded programme and the result has been to flood the literature with a mass of superficial results of no permanent value. Whenever plant breeding has been done with thoroughness, and on a sufficiently large scale, it has invariably been found that the inheritance of characters is by no means such a simple matter as at first supposed, and the investigations conducted at such centres as Slavöf explain why it is that the numerous attempts at plant improvement made at Agricultural Experiment Stations have not led to any striking results."

Extended trials have shown that high yield and good quality can be combined in the same plant, while it has been proved that the excellent properties of the Pusa wheats can be preserved under different environmental conditions. This latter thesis is developed in an important paper under the joint authorship of the Howards and Leake of Cawnpore. A series of Pusa wheats were grown under the varying conditions of ten stations in the chief wheat tracts of India, and the results carefully analysed. While it transpired that the conditions of climate and soil exercised a marked influence upon the character of the produce, it was also shown that the good characters of the Pusa wheats were largely maintained, and this in rain-fed land and under irrigation, in the lighter soils of the Gangetic plain as well as in the heavy black cotton soils of the Central Provinces, provided that careful attention was paid to good agricultural practice.

It is an interesting and important fact that the conditions tending to produce good quality in wheat are identical with those producing high yields. Further experiments with hot-weather cultivation tend to show that this treatment is cumulative in its effects, the best results having been obtained in the second and third years. The importance of drainage is emphasised by an ingenious experiment whereby it was demonstrated that the poor yield in badly drained lands is due to nitrogen hunger. Continuous growth of wheat on the same land without manure gave a still higher yield in this, the fifth, year of the experiment and it is considered that the limits of the capacity of the soil have probably been reached.

The principal wheat work in the near future, besides the purely Mendelian study of the inheritance of characters, will presumably be the maintenance in a pure state of the improved types raised. Ample arrangements are meantime being made for the multiplication of the best kinds. There is an increasing demand in Bihar and it is hoped that from 10,000 to 15,000 acres will be under these varieties during the

present year. It is proposed to put down 100 acres on Leake's new farm at Aligarh, while arrangements are being made in different tracts in the Central Provinces for raising a large amount of seed.

Cotton.—There is little work of a purely botanical nature to record regarding this crop. A paper in the press by Leake on the vegetative characters of cotton appears to consist largely of summaries of previous work, amplified by the results of various crossings. It deals with pollination, the colour of the corolla, the red matter in the sap, the leaf factor, the type of branching and the length of the internode. The systems of classification of cottons published by Todaro and Watts are criticised in the light of these new factors and it is specially pointed out that these systems have taken no account of the modes of branching in the various types. Using this character, Leake proposes a tentative classification which may be further considered when the paper is published.

Leake and Parr have contributed an important paper on the problem of improving the existing cottons in the United Provinces, in which they emphasise the importance of dealing only with readily tangible superiority in the introduction of new strains. From various considerations they come to the conclusion that, unless this superiority amounts to at least 25 per cent. of the value of the existing crop, it is idle to attempt to establish a new form. A careful study is made of the whole question in the light of experience gained during the work of recent years, and stress is laid on the improvement of the ginning quality as the most readily appreciable improved character. The authors lay great stress upon the importance, in any improved variety, of having some distinguishing mark by which, it can at once be recognised in the field.

The rest of the cotton work of the year consists of the continued segregation of various pure types from mixed crops and the founding of distributive agencies for such as have been proved to be more profitable than the local growth, whether in better lint, better ginning percentage, greater outturn and greater resistance to disease. It is obviously of little avail, in a crop where crossing in the field is a proved and constant factor, to be satisfied with small, isolated experiments, and every effort is made to deal with as large areas as possible and to ensure that the whole tract dealt with takes up the cotton distributed. From this point of view, the work of the year may be considered to be eminently satisfactory and large distributions have taken place in Tinnevelly, the northern districts of Madras, the Central Provinces, Bombay and the United Provinces, while interesting facts regarding the quality and outturn have been brought to light in the Punjab, the North-West Frontier Province and other parts of India. The most important types at present being dealt with appear to be Karungani in Tinnevelly, Tellapathi in the Northern Circars of Madras, Rosea in the Central Provinces and Bhuri

where wilt exists, Navasari (Broach) in the Deccan, improved Broach in Guzerat, Rosea in Khandesh, and white flowered (Varhadi) in Aligarh. Cambodia is making rapid progress in Madras where there is an increase in the total cotton area (an increase of 600,000 acres this year), undoubtedly largely due to recent introductions of better class cottons. Cambodia has also been proved to be eminently suited to the Dharwar American tract in Bombay and its cultivation there is rapidly extending.

Sugarcane.—In last year's report it was mentioned that the appointment of a full-time sugarcane expert was contemplated, whose main work would be the study of the sugarcanes of India and if possible the production of seedlings of improved quality. This appointment has been made during the year and a cane breeding station has been opened at Coimbatore. The preliminary work carried out by Barber while Government Botanist in Madras was referred to is last year's report and it was stated that the problem of raising canes from seed had been successfully solved. A considerable amount of progress has been made during the year under report.

It has been found that some of the North Indian canes, grown at Coimbatore, flower freely, but that the inflorescences, instead of being perfectly sterile as they appear to be in North India, are provided with large quantities of open anthers with fertile pollen. Provisional experiments have resulted in about 100 seedlings being raised from these canes. A much larger number of seedlings were obtained from the arrows of canes growing round Coimbatore and, although the arrowing season was exceptionally unfavourable because of heavy rains in the middle of November succeeded by a long spell of dry weather, some 12,000 to 15,000 seedlings were obtained in place of the 50 grown in the previous year. Of these, 2,000 have been selected for growing on and examination and most of them are thriving well at the time of writing. About 30 of last year's seedlings were closely studied from every point of view. Their morphological characters received special attention and these were compared with those of their parents with the idea of obtaining some information as to value of the characters from a systematic point of view, nothing being at present known on this subject. They were also very carefully studied in their earlier stages in order, if possible, to obtain criteria for the early rejection of unsuitable forms. The chemical analysis showed that the seedlings of the same parents varied a good deal in sugar content, but that those of different origin approximated somewhat to their parents in this character. A certain relation also appeared to exist between vegetative vigour and sugar content, and it is unfortunate that these seem to vary inversely, the most vigorous seedlings (one of which produced 143 strong canes in twelve months from sowing) having usually very poor juice. On the whole, the results are encouraging and one at least of the first year's seedlings

would appear to be worth trying under North Indian conditions, as it has a very fair proportion of sugar, pure juice and a considerable amount of vigour. It was unfortunately necessary to grow these seedlings on land entirely unsuited for sugarcane cultivation, and, for this reason, it has been thought wise to grow the whole again on the cane farm to check the results and, incidentally, to test the fixity of the characters observed.

The collection of varieties has been largely increased by the addition of canes collected during two long tours in North India and considerable progress has been made in the study of their morphological characters with the prospect of an ultimate classification of the Indian canes. In order to obtain some idea as to the canes most usefully employed as parents, a large number of analyses made in the past have been accumulated, special assistance having been given in this matter by the Imperial Agricultural Chemist and the Agricultural Chemist of Madras. The collection of varieties was greatly helped by the officers in charge of the Sabour, Pertabgarh, Aligarh and Gurdaspur farms.

Some interesting scientific results have accrued from the study of such wild Saccharums as have been obtained. Successful crosses have been made between *Saccharum spontaneum* and two North Indian forms, Chin and Shakarchynia, and this fact, coupled by strong resemblance in the vegetative characters, makes it appear probable that at any rate a number of the North Indian canes have arisen from this wild species, or are very closely allied to it. This conclusion has obtained a certain amount of support from the curious belief expressed by the cultivators round Gurdaspur that their canes, among the most primitive in India, have arisen from a wild grass which appears, from a cursory examination, to be a variety of *Saccharum spontaneum*. But this study of wild species was undertaken with the purpose of learning the systematic value of the vegetative characters, and a good deal of information has been obtained on this point. A number of seedlings were raised from *Saccharum spontaneum* which flowers freely round Coimbatore, and out of these two very different types have been selected for further study. Upon analysing their juice it was found that the more vigorous type contained nearly 3 per cent. of sugar while the stunted slow-growing form had nearly 5 per cent., a curious commentary on the relation between vegetative vigour and sugar content mentioned above in sugarcane seedlings. The other wild Saccharums studied, Narenga, Munja and arundinaceum, appear to differ widely from cultivated sugarcanes.

At Sabour, Woodhouse and Taylor continued their study of the canes of the tract, grown now in pure lines for four years. They have brought together the results of this study and these are awaiting publication.

At Aligarh the distribution of *Saretha Desi* continues to increase, some 200 acres being planted up of this variety in the neighbourhood of

the farm. As a certain amount of prejudice was expressed against this cane because of its habit of free flowering, Parr conducted experiments as to the relative *gur* production and suitability for seed purposes of flowered and unflowered canes. In each case the flowered canes were in no way behind the unflowered. The popularity of the Mauritius canes introduced at this farm continues and it is hoped that there will be a great extension of these kinds as they have proved superior to the local chewing canes.

At Jorhat in Assam, Meggitt has shown that several of the West Indian seedlings are capable of yielding large quantities of sugar per acre of good quality, and are therefore suitable for employment if sugar factories are contemplated.

In Madras the acreage under Red Mauritius continues to increase. A record specimen of Striped Mauritius has been figured, 29 feet long and with 23 feet of cane. On the West Coast B 208 appears to give better results than Red Mauritius and it is gradually supplanting that kind in some places, the sugar industry having received a great impetus from the work on the Taliparamba farm. Over 125,000 sets were distributed during the year.

Several new farms have either been opened during the year or are proposed in the main North Indian sugarcane tracts. One of the objects of these farms will be to test the canes produced at the Coimbatore farm.

Tobacco.—The Howards continue their study of this crop, the inheritance of leaf characters being the work of chief scientific interest during the year. The attempt to produce a good cigarette tobacco has met with considerable success and a consignment of leaf prepared from a selected type, specially cultivated and cured by a modification of the local method in Bihar, was valued at Monghyr at considerably above the normal price.

The Director of Agriculture in Burma considers that the haphazard distribution of Havana and Virginian seed in past years has had an appreciable effect on the quality of the local leaf. He proposes to continue and systematise these importations.

Soy Beans.—Woodhouse and Taylor have published an important Memoir giving the results of their work on Soy Beans for several years. It contains an account of the varieties found in the plains and hill tracts of Bengal and Bihar and Orissa and deals with the unit characters by which they are differentiated. It is interesting to note that many of the varieties from the hill tracts are similar to the Chinese types imported into America, while none of these types are found in the plains, on which the varieties are of long, straggling habit. The most interesting characters dealt with are the percentages of oil and nitrogen in the seeds, which appear to be inherited separately. The differences in the

oil content of pure lines of the different varieties were found to be inherited.

Agriculturally, some of the varieties have given satisfactory yields in the hills and plains, but in the plains the ordinary varieties have the disadvantage of occupying the land for two seasons. A sufficiently high price is not yet offered to encourage its growth for export.

Further work is being done with this crop at Sabour. It has been lately found that the Nepali variety of Soy Bean, which yields well and compares favourably with the best variety on the English market in size and oil content, has the single disadvantage of a brown seed coat.

Other Crops.—A large number of other crops have received attention during the year and some of these are mentioned here to indicate the wide nature of the field awaiting investigation.

Woodhouse has studied the extent of cross-pollination in the genus Phaseolus in Bihar.

Howard has grown certain grams along pure lines and noted considerable variations in their value, both as regards yield and quality. He considers that this crop presents a considerable margin within which improvements may be effected.

Burns has completed his survey of the peas and beans in the Bombay Presidency.

The expansion of the groundnut area continues, some 1,200,000 acres being under the crop. It has been justly pointed out that this extension has been coincident with the growth of the Agricultural Department in India, for every Provincial Department has been active in testing the kinds collected from all quarters of the globe, largely through the agency of the Palur farm in Madras, and distributing such forms as appeared to be suited to its own soil and climate. This distribution still continues on a large scale and several new tracts have been opened during the year.

Oil seeds are receiving a certain amount of attention. At Pusa the study of their pollination is being taken in hand. In Bengal, Hector has established pure lines of the Brassicas of the Province. He has collected and classified the tils and studied the amount of cross-pollination in the fields. Nothing that the oil content of the local kinds was uniformly inferior, he has introduced the best forms from other parts of India with a view to comparative growth and the improvement of the staple. Evans in the Central Provinces has been successful in the selection of better varieties and arrangements have been made for the pure growth of better class tils in 47 villages of Hoshangabad.

Howard has suggested that the present poor growth of indigo in Bihar is largely traceable to inferior cultivation and waterlogging. As

the result of trials at Pusa, he proposes wheat as a cover crop, care being taken to select an early, rapidly maturing variety. The question of seed farms having become urgent because of the increasing difficulty of obtaining good seed, he suggests Cawnpore or South Bihar as suitable places for the establishment of these.

The Howards have continued their study of the botanical characters of fibre plants.

Woodhouse has selected out a number of varieties of *Setaria italica* in Bihar and grown them on in pure lines.

Graham has made a survey of the Cucurbitaceæ of the Central Provinces. He has specially studied certain genera and separated out a number of distinct varieties.

Barber has made a study of the peppers of South India and arranged his collection of 1,143 sheets under a series of types. As remarked by Hooker in the Flora of British India, the genus requires revision by botanists in the field. This has now been largely accomplished and a summary note has been drawn up and placed in the Herbarium at Coimbatore for the guidance of authors of the forthcoming Flora of Madras. Several new species have been accurately studied and described, some of them being considered to be of high commercial value.

The flax experiments at Dhooriah by Vandekerkhove have been successful, showing a large profit, but the cultivation and preparation require a considerable amount of expert knowledge.

Hector has studied the Capsicums in Bengal and has demonstrated cross-pollination in the fields. The classification of those in the Central Provinces has been completed by Graham, specially pungent forms have been selected and largely distributed by seed.

Fruit-culture.—Fruit trees have received some attention. A fruit garden has been established near Quetta but, as the results will take some years to materialise, an older garden has been taken over in Quetta itself. Here various experiments are being conducted. Howard considers that the best form of packing is in chip and board boxes the materials of which are imported from Glasgow. The mango continues to receive a great deal of attention, especially in Bombay, and Hartless of the Saharanpur gardens has furnished a useful scheme for their preliminary classifications.

Work of great promise is being carried on by Robertson Brown in the Tarnab farm near Peshawar in fruit-culture. The introduction of ring-budding has been a great success and the plants so prepared from superior varieties of peaches, with large, well-flavoured fruit, are being readily taken up in large numbers by the local cultivators. The best method of packing these superior peaches has been decided on and it is expected that a large export trade will result.

Root Development.—Closely connected with the working of the soil is the effect of this on root development, but little account seems to be taken of the great diversity in the root systems of different kinds of crops. Parr has shown by experiment that, by deeper planting maize plants at Aligarh and earthing up a distinctly larger yield can be obtained and this method is being taken up by the neighbouring cultivators. Burns has continued his studies of the root systems of fruit-bearing trees in Bombay. Howard has made the interesting observation that, when the roots of banyans are severed, they not infrequently re-unite by a process of natural root-grafting.

Barber in Coimbatore has made a survey of the root systems of the crops growing on the farm in mixed black cotton and red soil. Each system has been carefully dissected out, noted and photographed to scale, and interesting facts have been brought to light concerning the duration of crops. A special study was made of the species of cottons growing in the tract and it was recorded that Cambodia was capable of developing a root system suggesting that it might be grown in many parts of the Presidency without irrigation. The root systems of the tamarind, nim, portia (*Thespesia populnea*), babul and agathi (*Sesbania grandiflora*) received special attention with regard to their influence on the crops around them.

Part II.—FOREST BOTANY.

BY

R. N. PARKER, F.C.H.,

Forest Botanist.

Œcology of sal.—Experiments carried out during the year by the Forest Botanist in growing *sál* seedlings (*a*) *in situ* in typical local grasslands and (*b*) at Dehra Dun in large flower-pots in soil collected from the same grasslands have corroborated the fact mentioned in previous reports that the dominant species of grass is an accurate indicator of the local conditions of soil and of the suitability or otherwise of the area occupied by these grasses for the growth of different forest trees. The work done up to date shows that, for the successful growth of *sál* seedlings, the soil must be well aërated and must at the same time be capable of retaining not less than 10 per cent. of moisture throughout the hot season. In a badly aërated soil the percentage of germination of *sál* is lower and the percentage of deaths during the rains is higher than in a well-aërated soil. In addition to this, the average length of root of one-year-old *sál*

seedlings is 12″ and 30″ in badly and well-aërated soils, respectively. Thus the former plants are also more subject to the injurious action of drought, seeing that their roots are situated in the upper layer of soil which dries out rapidly in the hot season. An interesting fact brought out in the experiments is that by simple mechanical pressure (even when the soil is practically dry), such as would be caused by the tread of grazing animals, a soil known to be suitable for the growth of *sál* can be rendered totally unsuitable on account of its bad aëration.

An important point investigated during the year was that of the heavy mortality of *sál* seedlings which usually occurs in the local *sál* forests during the rains, in July-August. The experiments carried out clearly showed that the responsible factor was not shade, *i.e.*, an insufficient intensity of light. The light intensity in the forests when the mortality ranged from 80—90 per cent. of deaths was 0·02 to 0·05. Under artificial shades, on the other hand, *sál* seedlings have been grown successfully with a light intensity as low as 0·007, the mortality during the rains being only 20 per cent. So far as the work has gone at present it indicates that the dominant factor here responsible is bad soil aëration which is brought about chiefly by (*a*) the shade in the forest preventing free air-circulation and thus decreasing the evaporation of water from the soil and (*b*) a high percentage of humus in the surface soil which greatly increases its capacity for holding water. A set of experiments has been designed which should further elucidate this point next year and it has been considered advisable to defer publication until these results are available.

Forest grasses.—The study of the species mentioned in last year's report was continued while the work undertaken in collaboration with Mr. Raitt on those species likely to be valuable for paper-pulp was completed and the results of the latter are now in the press. The following widely distributed and gregarious species have all been found to constitute a first class material for the manufacture of paper-pulp and they can all be treated either separately or in mixture without reducing the value of the product:—

Saccharum spontaneum, Linn.
,, *arundinaceum*, Retz.
,, *Munja*, Roxb.
,, *Narenga*, Wall.
Anthistiria gigantea, Cav.
Arundo Donax, Linn.
Phragmites Karka, Trin.

The following species, although somewhat inferior in quality and strength of fibre to the above, have been found to be admissible

in moderate quantity with them without material prejudice to the yield and quality of the pulp:—

Saccharum fuscum, Roxb.
Andropogon intermedius, Br.
Vetivera zizanioides, Stapf.
Andropogon Nardus, Linn.
Erianthus Ravennæ, Beauv.

A negative result of considerable importance is that the very common *Andropogon contortus*, Linn., the well-known Spear grass of the plains, is of no value and is quite inadmissible in mixture. It has been found that the maximum yield of cellulose is obtained if the grasses are cropped when flowering and as the culms of some of the species require more than one year to attain maturity and flower, this means that they must be worked on a rotation. One species, *viz.*, *Saccharum arundinaceum*, Retz., the culms of which require 3 or 4 years to attain maturity, has been found to give an average annual yield of 14 tons of dry material per acre per annum which is believed to be the highest yield of any pulp-yielding species. (*Hedychium coronarium* has been recently reported to give 10 tons per acre per annum which is apparently the next highest yield.) Another of the species dealt with (*Anthistiria gigantea*) has been found to yield a pulp of quite exceptionally high quality.

Local Forest Floras.—The Forest Botanist prepared a detailed scheme for the preparation of descriptive lists in all provinces for the consideration of the Board of Forestry which met at Dehra Dun during the year. On this note the Board passed the following resolutions:—

(1) That detailed Forest Floras are useful for purposes of reference and that their ultimate publication is an object which should be kept steadily in view.

(2) That the preparation of detailed Floras is not of such urgent importance at the present time as is preparation of descriptive lists.

(3) That the scope and general character of the descriptive lists as detailed in the note are generally suitable.

(4) That the preparation of descriptive lists should be undertaken in the various provinces as soon as circumstances permit.

There is thus good reason to believe that this important work will now be systematically and energetically taken in hand.

A list of trees, shrubs, etc., recorded from Burma with vernacular names was issued by Mr. Lace, Chief Conservator of Forests, during the year.

List of papers on Economic Botany.

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BEALE, R. .	. Studies in Vegetable gland tissues. I. (*Poona Agri. Col. Magazine, iv, 267, 1913.*)
BOMBAY DEPARTMENT OF AGRICULTURE.	Treatment of a Mango Plantation. (*Agri. and Co-operative Gazette, viii, No. 10, 1912.*)
BROWN, W. ROBERTSON.	Annual Report of the Agricultural Stations of the North-West Frontier Province for 1911-12.
BROWN, W. ROBERTSON.	Italian Rye Grass in Peshawar. (*Agri. Jour. of India, vii, 391, 1912.*)
BROWN, W. ROBERTSON.	English Oats in Peshawar. (*Agri. Jour. of India, vii, 393, 1913.*)
CHIBBER, H. M.	. Some Promising Leguminous Crops. (*Poona Agri. Col. Magazine, iv, 252, 1913.*)
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CLOUSTON, D. .	. Transplantation of Rice in Chhatisgarh. (*Agri. and Co-operative Gazette, Central Provinces, ix, No. 5, 1913.*)
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GRAHAM, R. J. D.	. Robber Plants. (*Agri. Co-operative Gazette, Central Provinces, ix, 1913.*)
HAINES, H. H.	. *Trees, Shrubs and Economic Herbs of the Southern Circle, Central Provinces.* (*Ind. For., October 1912 and February 1913.*)
HARTLESS, A. C.	. Report of the Government Botanical Gardens, Saharanpore, for the year ending 31st March 1913. (*Allahabad, 1913.*)
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,, ,, . . *Burmese Kaing Grass. (Ind. For., October 1912.)*

,, ,, . . *Useful Exotics in Indian Forests. (Ind. For. Rec., iv, 3, January 1913.)*

,, ,, . . *Albizzia Lathamii*, Hole. *(Ind. For. Rec., iv, 4, January 1913.)*

,, ,, . . *Note on the chief Fodder Grasses of Indian Forests. (Ind. For., February 1913.)*

,, ,, . . *A Notorious Indian Fodder Grass. (Ind. For., June 1913.)*

HOPE, G. D. . . A Method of renovating tea bushes by pruning. *(Quarterly Journal of the Indian Tea Association, 57, 1912.)*

,, ,, . . The Value of Leguminous trees in tea gardens. *(Quarterly Journal of the Indian Tea Association, 64, 1912.)*

HOPE, G. D., & TUNSTALL, A. C. Green Manuring, Parts I and II. *(Quarterly Journal of the Indian Tea Association, 99, 1912, and 22, 1913.)*

HOWARD, A. . . Natural Root-grafting. *(Agri. Jour. of India, viii, 185, 1913.)*

,, ,, . . Some Aspects of the Agricultural Development of Bihar. *(Bull. No. 33, Agri. Res. Instt., Pusa, 1913.)*

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BOTANY.

III.—MYCOLOGY.

BY

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Imperial Mycologist.

I.—Plant Pathology.

Agricultural Research Institute, Pusa.—The following is an account of the chief diseases of plants investigated at Pusa during the year.

Rice diseases.—A disease of inundated rice, of a very serious nature, has broken out in the deltaic districts of Eastern Bengal, where it is locally known as *ufra*. Much time was given to its investigation. It has been found to be caused by a minute parasitic nematode worm, of the genus *Tylenchus*. Though not mycological, it is referred to here, as, in the absence of any agricultural Helminthologist in India, its further investigation has been taken up by the writer. The parasite, a hitherto undescribed species, attacks especially the deep-water winter rice so extensively grown in the area referred to, and the intensity of the attack is such that affected fields are frequently not considered worth harvesting. In the backward state of agricultural information in Eastern Bengal, it is difficult to arrive at even an approximate estimate of the losses, but they are undoubtedly very heavy and there is evidence that the disease is spreading. The parasite is allied to two of the worst worm parasites of crops known, *Tylenchus tritici* and *T. dipsaci*. It appears to be strictly parasitic on rice, being unable to grow and multiply in the absence of living rice plants. It feeds by piercing the epidermis of those parts of the plant where the outer wall is unthickened and not silicified and, consequently, is restricted to certain definite parts of the plant: the apex of the shoot, the young leaves, above the upper stem nodes, and the young ear being the chief. The result of its attacks is to prevent the ear from maturing properly and there is total or partial loss of the grain. It passes the period between successive crops coiled up, in a resting condition, in the stubble and can stand drying in this condition for over a year. No evidence has, as yet, been obtained that it hibernates in the soil; if subsequent work confirms this, there is a good

prospect of being able to fight it by destroying all stubble left after harvest, and experiments in this direction are being carried out.

The chief fungus diseases of rice studied were bunt, caused by *Tilletia horrida* Tak., false smut caused by *Ustilaginoidea virens* (Cke.) Tak. and a disease caused by *Sclerotium Oryzæ* Catt. Accounts of these diseases have been published since the close of the year under review.

Root rot of various crops.—A description of the morphology and parasitism of two species of the form genus *Rhizoctonia,* soil parasites which attack the underground parts of several crops, was published. Cotton, jute, groundnut, cowpea, potatoes and sesamum are amongst its victims. More recently, it has been found to cause opium blight and to damage lucerne. The published investigations deal with two species, *R. Solani* Kühn on jute, cotton, potato, groundnut and cowpea and *R. violacea* Tul. on groundnut and cowpea. The latter is shown to be an imperfect stage of the basidiomycete *Corticium vagum* B. & C. Details of their morphological characters in culture and their behaviour as parasites, are given.

Phytophthora investigations.—Two species of this most destructive genus of fungus parasites, *Ph. parasitica* Dastur and *Ph. Colocasiæ* Rac., have been under study, and the results were published. *Ph. parasitica* causes a disease of young castor plants, being the most serious disease of the crop known. It was obtained in pure culture and this permitted of a very full study of its characters and parasitism. The chief interest centres in the discovery of a new type of reproduction, a discovery which was anticipated by a British Mycologist, working with an allied species, shortly before the publication of the paper. A very complete series of inoculation experiments was carried out, potato, tomato, brinjal, til and several other plants proving susceptible to attack.

Ph. Colocasiæ attacks the country vegetable, *Colocasia antiquorum*, and, under certain conditions, causes much damage both to the growing crop and, subsequently, to the stored corms. The intensity of the attack is closely dependent on the character of the monsoon, being worst in wet years. The parasite was cultivated artificially and a large series of inoculation experiments carried out, which showed that it has a very restricted range of victims. It possesses the same remarkable type of reproduction as *Ph. parasitica.*

More recently *Ph. infestans*, the cause of the well-known potato blight, has been under study, a serious outbreak having occurred in Bihar and Bengal last year. It has also been obtained in pure culture and it is hoped to get some light on the reason why it is so rarely found in the hotter parts of India.

Sugarcane diseases.—The progress in the investigation of several diseases of this crop is referred to in the Pusa Annual Report for 1911-12.

The work has extended over a number of years, owing to difficulties encountered in carrying on field experiments. It has been so far completed as to allow of the preparation of two Memoirs now in the press, one on red rot (caused by *Colletotrichum falcatum* Went), and a second on some new sugarcane diseases. The chief points elucidated are the channels of natural infection of the crop, in some of the more important stem diseases, and the methods of control to be adopted in practice. These will be referred to more fully in the next report.

Wheat rust.—A severe attack of wheat rust, the first for a number of years, occurred in the Central Provinces in 1912. It was found that orange rust (*Puccinia triticina*) was responsible for much of the damage, though in ordinary years scarce in that part of India. Black rust (*P. graminis*) was also severe. Hence, in breeding rust-resistant wheats, the behaviour to these two rusts must be chiefly considered and, as orange rust may be absent in ordinary years, it may be necessary to carry out some of the work in parts of India where orange rust occurs annually.

Anthracnose of sisal hemp.—This was definitely proved to be due to the fungus *Colletotrichum Agaves* Cav. previously suspected to be its cause. It infects various species of *Agave* readily, and produces a characteristic leaf disease. Collecting and burning diseased leaves, and spraying with Bordeaux mixture, are recommended as measures likely to check the disease.

Damping off.—This seedling disease, caused by *Pythium de Baryanum* Hesse, was not previously reported from Asia, but has been found to occur occasionally at Pusa. It was studied, and some doubtful points in its morphology cleared up. In temperate countries it causes a good deal of loss, but does not appear to be a serious danger in India.

Cereal downy Mildews.—These diseases, caused by members of the genus *Sclerospora*, appear to be of greater importance in India than elsewhere. Maize, several of the more important millets and a fodder grass, are amongst the crops affected. The maize mildew appeared at Pusa for the first time last year, and is probably a recent importation from Java, where it has been known since 1897. It has not yet been found in any other country, but in Java causes much loss. From its investigation at Pusa, it was found to be closely allied to the form on jowar (*Andropogon Sorghum*) and to be a true *Sclerospora*, not a *Peronospora* as stated by investigators in Java. It was also shown that the resting-spore stage described in Java, by which the disease was supposed to be perpetuated, had in reality nothing to do with the fungus, being merely the cystic stage of a Protozoon. Nothing is known of the life-history of the *Sclerosporas*, and observations are being continued in the hope of determining how the parasite persists from one season to the next. Until this is decided, it is not possible to find a rational method of con-

trol, and the only measure that can be recommended is to pull out and destroy all diseased plants, which can only be done in mild attacks.

Mr. Kulkarni, Mycological Assistant, Bombay Department of Agriculture, has given reasons for separating the *Sclerospora* on jowar from that on bajri (*Pennisetum typhoideum*) as a distinct variety, to which he has given the name *Sc. graminicola* var. *Andropogonis Sorghi*. He has also furnished useful notes on the field characters of these mildews.

Indigo blight.—This obscure disease has been under study for some time, but no parasitic organism has been found constantly associated with it and it is considered to be non-fungal in origin. A considerable number of different organisms, mostly of the class known as weak parasites, were isolated from individual plants, in various stages of the disease, but none proved capable of reproducing it. The mycological side of the enquiry has, therefore, been abandoned.

Miscellaneous.—Notes are given in the Annual Report of the Mycological Section, Pusa, for 1911-12, on a number of other diseases of plants studied during that period. The more important were cotton wilt, anthracnose of plantains, foot rot of papaya, lucerne and cauliflower mildews and a number of forest tree diseases. The successful treatment of oat smut by formalin steeping is recorded, and notes are given on the areca palm disease in North-Eastern India, believed to be caused by *Fomes lucidus* (Leys.) Fr.

Provincial Departments of Agriculture.—The following are the chief items of mycological work carried out by Provincial Departments of Agriculture and referred to in the reports published during the year.

Madras.—Mr. McRae continued the campaign against bud-rot of palms (caused by *Pythium palmivorum* Bult.) in the Godavari and Kistna Districts. Some extensions of the disease outside the area covered by the operations were discovered and dealt with. In Kistna there is a distinct decrease in the area affected, as a result of the work, but the checking of extension in the upland forest area is a serious problem. In Godavari the area remains practically the same and there is no decrease in the number of trees cut periodically. In a paper published in the *Agricultural Journal of India*, Mr. McRae calls attention to the danger of allowing palms, which have spots caused by the parasite on the expanded leaves, to remain uncut. The fungus in this position is exposed to wind dissemination and each such tree serves as a centre of spread to surrounding palms. Fortunately the number of cases in which the parasite attacks the leaf blades is small. As there is a difficulty in inducing the ryots to allow these to be cut, a proposal has been made to employ some form of compulsion.

Mr. McRae carried out extensive experiments in spraying areca palms, affected with the *Koleroga* or *Mahali* disease (caused by *Phytophthora omnivora* var. *Arecæ* Coleman), in South Malabar, with such success that the owners have asked that the work should be continued. The increased profit per 100 trees sprayed was over Rs. 20.

A bud-rot of coconuts was reported from Malabar. It was at first believed to be identical with that of Cuba and the West Indies, the cause of which is *Bacillus coli*, but recent reports indicate that it is due to *Pythium palmivorum*. It is, at present, impossible to gauge the importance of this outbreak, but the chief fear which has always been felt by those responsible for the work against this parasite in Madras, has been that it should develop with virulence in the enormously valuable coconut plantations of the West Coast.

Other work in Madras included unsuccessful attempts to secure inoculations with the false smut of paddy [*Ustilaginoidea virens* (Cke.) Tak.], stringent selection of the sugarcane crop at Samalkota with a view to checking red rot, and the study of several diseases of various crops.

Mysore.—Dr. Coleman continued work in connection with the *Koleroga* disease of areca palms, and the parasitism of *Fomes lucidus* on the same tree.

Bombay.—Mr. Ajrekar published a note on the rust of castor (*Melampsorella Ricini* de Toni). Work in connection with the control of *Koleroga* of areca palms and red rot of sugarcane was continued.

Central Provinces.—Work was confined to observations on the behaviour of varieties of wheat to rust, with a view to securing rust-resisting strains, and further tests of the immunity of buri cotton to wilt. The latter were eminently satisfactory, almost complete immunity being shown, even when planted in fields very severely infested with wilt. As the variety yields the cultivator about Rs. 40 less per acre than the cottons ordinarily grown, its use is likely to be restricted to wilt-infested areas.

Bihar.—Mr. Basu studied the outbreak of *Phytophthora infestans* on potato and has published a note on it since the close of the year under review.

Burma.—The anthracnose of cotton (caused by *Colletotrichum Gossypii* Southw.) was found on Pernambuco tree-cotton. A short note giving suggestions for its control was published as a departmental leaflet.

Indian Tea Association.—Mr. Tunstall has contributed a number of notes on tea diseases to the Association's Quarterly Journal. These deal chiefly with root diseases, the commonest being those caused by *Ustulina zonata* Lev., *Hymenochæte noxia* Berk. and *Botryodiplodia*

Theobromæ Pat. Besides the measures previously recommended for the check of these diseases, experiments were carried out with a new treatment, consisting in the application to the soil of ammonium sulphate and lime in equal parts, after removing all dead roots. This results in the liberation of ammonia, which is stated to inhibit the growth of the parasite.

Of leaf diseases the chief referred to are blister blight, caused by *Exobasidium vexans* Mass., and copper blight, caused by *Læstadia Theæ* Rac. Blister blight was observed in Darjeeling and North-East Assam. It has been found to persist through the cold weather on old nurseries, seed gardens and abandoned tea, and it is recommended that attention should be directed to preventing infection from these sources. None of the plucking area should be left unpruned and no abandoned tea or old nurseries should be kept; all seed gardens should be sprayed with Bordeaux mixture; and planters should unite so as to secure concerted action in stamping out the disease. Copper blight is said to be on the increase, but to cause comparatively little damage at present.

II.—Systematic Mycology.

There is little to record under this head during the year. A few new species have been described from India by Saccardo and Sydow. Dietel points out that the common Himalayan rust of wild vines cannot be identified with *Phakopsora Vitis* Syd., but is a distinct species, which he has named *Phakopsora cronartiiformis* (Barcl.) Diet. Theissen has commenced the publication of a compilation, giving a list of the Fungi of India, in the Journal of the Bombay Natural History Society.

List of Publications.

AJREKAR, S. L. . . The Castor Rust (? *Melampsorella Ricini* de Toni). (*Journ. Bombay Nat. Hist. Soc., xxi, p. 1092, 1912.*)

Annual Reports of the Agricultural Research Institute and College, Pusa, and of the Provincial Departments of Agriculture.

BUTLER, E. J. . . Ufra disease of Rice. (*Bull. of the Bureau of Agric., Intell. and Plant Diseases, 3rd year, No. 7, p. 1661, 1912.*)

,, ,, . . Pythium de Baryanum Hesse. (*Mem. Dept. of Agri., India, Bot. Ser. V, No. 5, 1913.*)

,, ,, . . The downy mildew of Maize [*Sclerospora Maydis.* (Rac.). Butl.] (*Ibid.*)

BUTLER, E. J. .	. Note on the investigation of diseased conditions of the Indigo crop in 1911-1912. (*Read at the General Meeting of the Bihar Planters' Association, Jan. 29th, 1913.*)
BUTLER, E. J., & KULKARNI, G. S.	Colocasia Blight, caused by *Phytophthora Colocasiæ* Rac. (*Mem. Dept. of Agric., India, Bot. Ser. V, No. 5, 1913.*)
DASTUR, J. F. .	. On *Phytophora parasitica* nov. spec., a new disease of the Castor oil plant. (*Mem. Dept. of Agric., India, Bot. Ser. V, No. 4, 1913.*)
DEPARTMENT OF AGRICULTURE, BURMA.	Anthracnose (a disease of the Cotton plant). *Cultivators' Leaflet No. 38, 1912.*)
DIETEL, P. .	. Eine Bemerkung über *Uredo cronartiiformis* Barcl. (*Ann. Mycol., x, p. 385, 1912.*)
KULKARNI, G. S.	. Observations on the downy mildew [*Sclerospora graminicola* (Sacc.) Schroet.] of Bajri and Jowar. (*Mem. Dept. of Agric., India, Bot. Ser. V, No. 5, 1913.*)
MCRAE, W. .	. Rows of spots on the leaves of Palmyra palms, caused by the bud rot fungus, *Pythium palmivorum* Butl. (*Agric. Journ., India, vii, p. 272, 1912.*)
SACCARDO, P. A.	. Notæ mycologiæ. (*Ann. Mycol., xi, p. 14, 1913.*)
SHAW, F. J. F. .	. The morphology and parasitism of *Rhizoctonia*. (*Mem. Dept. of Agric., India, Bot. Ser. IV, No. 6, 1912.*)
,, ,, .	. Anthracnose of Sisal hemp. (*Agric. Journ., India, viii, p. 65, 1913.*)
SYDOW, H. & P.	. Novæ fungorum species. (*Ann. Mycol., x, p. 405, 1912.*)
THEISSEN, F. .	. The fungi of India. (*Journ. Bombay Nat. Hist. Soc., xxi, p. 1273, 1912, and xxii, p. 144, 1913.*)
TUNSTALL, A. C.	. Notes (in *Quart. Journ. of the Indian Tea Assoc., 1912 and 1913*).

IV.—AGRICULTURAL BACTERIOLOGY.

BY

C. M. HUTCHINSON, B.A.,

Imperial Agricultural Bacteriologist.

Agricultural Bacteriology.—Nitrogen supply in the soil as affected by intervention of bacteria has been the principal subject of enquiry; in the previous year attention was confined to the conditions under which organic nitrogen of manures and residues was converted into ammonia and nitrates; this line of enquiry affords sufficient work to occupy the whole time of any establishment for many years, but it has been considered advisable to add to it an investigation of the natural conditions under which nitrogen is taken from the air and added to the soil in this country. This if carried out thoroughly would also involve a very large amount of work, but it seems advisable in dealing with such a question as soil bacteriology in this country, where no work on this subject has been carried out before, to make preliminary enquiries, however superficial, on similar important questions, in order to gain some idea of the most useful direction in which to pursue the subject more fully. This is the more necessary on account of the still early stage of development of soil bacteriology as a science, and the fact that many fundamental theories connecting bacterial action with soil fertility have not yet been accepted as axiomatic. It is perhaps unnecessary to emphasize the importance of the question of nitrogen fixation, but it may be pointed out that there is very good reason for supposing that upon this depends the ultimate prosperity of a country, the mineral wealth of which not being commensurate with its agricultural area and population debars it from the purchase of adequate supplies of nitrogen from external sources. At the present time the need of nitrogen in India is becoming increasingly greater owing to the introduction of intensive cultivation, although up till now the soils of this country as a whole have been preserved from undue depletion by the generally superficial and extensive nature of the cultivation employed, which has prevented large crops from being taken off the land, after the reduction of the original virgin soil to the normal level of fertility by the growth of crops. At the same time deportation of nitrogen in the form of produce exported from areas in which it was grown has not been excessive, and in the case of rice much fertilization of the soil takes place by deposition of organic matter carried down from jungle tracts by the irrigation water.

Nowadays, however, this state of affairs is being rapidly altered owing to the expansion of Indian trade, which not only transports food stuffs from agricultural districts to feed the increasingly large populations of cities, but carries enormous quantities of produce out of the country, including not only cereals, oilseeds and fibres, but bones and hides, which represent nitrogen collected from very extensive areas of land. If now, in addition to this constant drain upon the nitrogen resources of the soil, intensive cultivation is introduced, meaning the more rapid conversion of non-available plant food, especially nitrogen, into the available condition, depletion will certainly follow, differing in intensity from such a result in temperate climate as the average soil temperature in India differs from that in Europe, but in an even higher degree. This difference due to temperature has been observed and measured in this laboratory as affecting ammonification, nitrification, and the formation of carbon dioxide by oxidation of the organic matter of the soil, and is not one of a slightly higher degree, but may easily attain to an increase in rate of one hundred per cent. or more; the concurrent loss of nitrogen is not to be measured, therefore, only by the increased crops taken off the land, but by losses in the form of ammonia and of nitrate washed out during the rains from fallows in well drained areas.

A further point must not be overlooked; on the credit side of the nitrogen account must be placed the addition of this element to the soil through the intervention not only of leguminous plants but of nitrogen fixing members of the soil flora such as Azotobacter and Clostridium; the physiological activity of these organisms, however, is strictly limited by soil conditions, and especially in the case of the former by the supply of carbohydrate food, so that should intensive cultivation, carried out without regard to this aspect of the case, lower the supply of organic matter beyond the optimum point for nitrogen fixation by the above-mentioned organisms, this source of nitrogen would be cut off, and the discrepancy already existing between the two sides of the account would be further increased, probably in geometric proportion.

During the past year Azotobacter has been found in all Indian soils examined, including those of such widely differing character as may be found in Sind, Nagpur, and Assam; pure cultures of *A. Chroococcum* from such various sources exhibited nitrogen fixing power very similar to that recorded from European strains, its physiological activity depending upon appropriate supplies of water, air, lime, and especially of carbohydrate food. It is intended to carry out a general survey of Indian soils to get some idea of the distribution of this and similar organisms and the conditions under which they may most readily carry on nitrogen fixation in these soils.

The green manuring experiment begun in collaboration with the Imperial Agriculturist during the previous year was carried on and will continue in 1913-14. The successful use of a green manure crop was found to depend almost entirely upon the incidence of rainfall succeeding the burying of the crop, partly owing to the loss of soil moisture by transpiration during the growth of the green manure, and partly to the necessity for providing a considerable percentage of soil water to ensure the proper decomposition of the buried material. Further experiments during the current season include a special method of dealing with a green manure crop designed to avoid the loss due to want of sufficient soil moisture to ensure complete decomposition after burying; this method consists in hastening the initial stages of decomposition by steeping the cut crop in water and then fermenting it in heaps, under which conditions the less readily decomposed cell walls and lignified tissues are rapidly attacked by bacteria favoured by semi-anærobic conditions; the fermented material is then used in the same way as farmyard manure. The advantages of this method, in addition to the principal one of eliminating the uncertainty of the rainfall as a factor in decomposing the buried green material, include the possibility of applying the fermented manure at the best rate per acre and at the best time for producing its optimum manurial effects; at the same time it is not necessary to grow the green manure crop on the land which is to carry the "rabi" crop intended to benefit by its manurial effect; in some cases this might be of great advantage with regard to the depletion of the soil moisture consequent on transpiration during the period of growth of the green manure crop. This method of dealing with a green manure crop closely resembles the practice in indigo-growing districts of manuring tobacco and other soils with the refuse ("seet") from the indigo factory, which is obtained by steeping the cut indigo plant in water for some 24 hours and subsequently allowing the sodden plants to lie in heaps in which fermentation goes on; the rotted material thus produced is generally applied to tobacco lands, the rented value of which depends almost entirely upon the local availability of the indigo "seet."

The field experiments with green manure in 1912-13 included the growth of a "rabi" crop (wheat) on the experimental area. In no case was there any increase in yield from the green manured plots and in many there was a decided falling off. There can be no doubt that this result was due to the failure of the generally expected rainfall in September and October (locally known as the "Hathia"), as it was found on examination that the buried stems of the green manure had failed to undergo complete decomposition.

Laboratory experiments showed that the nitrate formed from the buried plant tissues increased in amount up to the end of eight weeks from the time of turning into the soil, provided the water supply was

kept up to at least 16 per cent. of the soil weight, but after this period a steady diminution took place, so that after twelve weeks a smaller quantity of nitrate than that present at the end of the eighth week was invariably found. The cause of this loss was not discovered, although it may be conjectured that it was due to the demands of the soil organisms, for nitrogen, but its invariable occurrence is interesting as helping to explain the already well-known fact in field practice that too long an interval between the burial of a green manure and the sowing of the succeeding "rabi" crop is prejudicial to the latter so far as any improvement which may be expected from the use of the former is concerned.

The results of the first year's experiments on green manuring are being published in the form of a bulletin.

Further work on the occurrence of bacterio-toxins in soil, their relation to infertility and the action of tillage, drainage, and manurial application in neutralizing them, was carried out.

Biological analyses of various soils were made and further modifications of the method introduced; this subject is still in a very early stage of development, especially so far as interpretation of results is concerned, but it is hoped that further experience and modification of the method will lead to its successful application to the solution of various soil problems. At present it is possible to determine the optimum moisture content of a soil for certain biological processes necessary for fertility, to ascertain approximately the organic manures most suitable for application, with the important reservation that the sample experimented on may not be truly representative of the area to be treated; this source of error is greatly minimised by the use of large samples and the introduction of the method of using soil media in place of inoculating liquid media with small samples of soil; thus in the old method one gram of soil was generally used as inoculum and the biologic activity of the soil as a whole was judged therefrom. Whereas in the method now used, estimations of nitrifying and ammonifying capacity and efficiency, and general biologic activity, are made with samples varying from 400 grams to 1,200 grams.

Special Enquiries.

Sewage farms.—At the request of the Principal of the Agricultural College, Nagpur, a series of investigations was commenced with a view to determining the effects of the application of the sewage upon the biological condition of the soils of the College farm. The writer visited Nagpur and inspected the farm soils and the sewage installation, and discussed with Mr. Allen and Mr. Plymen the general arrangement of the experimental plots to be put under treatment. An arrange-

ment was made for sending periodic samples to Pusa for examination and at the same time Mr. Plymen agreed to carry out chemical analyses to determine nitrate at Nagpur.

Rice.—An experiment was arranged to determine the effect of soil toxins upon the growth of the rice plant; this was in connection with the work of the Imperial Mycologist upon the "Ufra" disease of this crop, as it was considered possible that the incidence of this disease might depend upon adverse soil conditions. Rice was grown in pots in soil to which large quantities of mustard cake were added, it having been found that the initial stages of decomposition of this manure gives rise to bodies which are toxic to plants. The pots were arranged so that in one set lack of drainage should allow of accumulation of the toxins produced, whilst in the other continuous percolation removed them in solution. The results completely verified expectation, as not only was growth seriously interfered with in the undrained pots, but the root formation in the drained set showed that the toxins carried down by the percolating water had inhibited root growth in the lower soil, whereas in the undrained series more root development took place below than above. No symptoms of "Ufra" appeared, but Dr. Butler has now demonstrated conclusively the connection between this disease and the presence of nematodes in the plants, nor does it appear that soil conditions adverse to healthy growth render the latter more liable to attack. The investigations carried on by Mr. Harrison, Agricultural Chemist to Government of Madras, as to the nature of the changes taking place in soil under rice cultivation are referred to in the section dealing with Agricultural Chemistry.

Indigo disease.—Plants of Java variety were grown and kept under observation for symptoms of wilt in order to determine a possible bacteriological origin of this disease; this work will go on through the current season.

Potato rot.—An extensive series of investigations was carried out, mainly by Mr. N. V. Joshi, First Assistant to the Imperial Agricultural Bacteriologist, as to the cause responsible for the very common rotting of tubers in store. The Economic Botanist to the Government of Bihar and Orissa, at whose instance this work was undertaken, provided samples from various godowns in Bihar, and others were received from Poona. Two rotting bacteria were found to be present invariably and these appear to be normal in Indian soils. It was found that rotting could take place in presence of these bacteria either if the dry tubers suffered mechanical injury or if the uninjured tuber were kept under conditions in which its surface could remain moist for a few hours. Thus tubers stored in sand to keep out potato moth can be attacked, if the rotting organisms are present, either through bruising due to careless handling or by reason of the sand not being perfectly dry, or by contact

between a rotting potato exuding moisture and a sound one; this last possibility necessitates frequent examination of stored tubers and picking out of rotten ones. Various antiseptics were tried on a small scale, of which copper sulphate proved the best; this will be tested along with other preventive measures in the ensuing season.

Publications.

"*Drainage in Rice Soils*" by C. M. Hutchinson, Imperial Agricultural Bacteriologist. (*Agricultural Journal of India, Volume VIII, No. 1, January 1913.*)

FORESTRY.

I.—SYLVICULTURE.

BY

EDWARD MARSDEN,
Sylviculturist.

Statistical work in typical forest crops.—The formation and measurement of sample plots, permanent and temporary, was continued and extended, 31 of the former and 8 of the latter being laid out in the United Provinces, and 31 of the former and 13 of the latter in the Punjab, a total of 62 permanent plots and 21 temporary plots during the year. In addition, 7 experimental plots were laid out in the Punjab with the object of ascertaining the most favourable conditions under which natural regeneration of *Pinus longifolia* could be obtained in practice. The species taken in hand were *Shorea robusta*, *Dalbergia Sissoo*, *Cedrus Deodara*, *Pinus longifolia*, *Pinus excelsa*, and *Quercus dilatata*.

In the permanent sample plots, the volume of timber standing is measured by means of dividing the total number of trees into inch-classes, and then by felling sample trees representative of three or four groups in which the inch-classes are incorporated. The plots will be remeasured every five years and will thus provide a basis for determining the rate of growth, the degree of density which produces the best results in the quality and quantity of timber formed, as well as forming a nucleus for the ultimate preparation of yield-tables. With the object of effecting a similarity and if possible an uniformity in the system adopted for measuring sample plots and typical trees, a note was published on the method used in the Sylviculture Branch at the Forest Research Institute for the collection and tabulation of statistical data. It is hoped that measurements carried out by Forest Officers working independently may follow the lines indicated, as only by an uniformity in the system of measurement and tabulation will it be possible to co-ordinate and compile all the figures collected.

The Sal tree (Shorea robusta).—A Bulletin was issued by Mr. Troup dealing with the causes and effects of the drought of 1907 and 1908 on the *sál* forests of the United Provinces, and in the course of his investigations it became clear that the subsoil is, in the case of *sál*, a

factor of preponderant importance, whole tracts of forests being destroyed or not according to the hygroscopicity of the subsoil. Experiments are in progress in the sylvicultural gardens to ascertain whether the presence of "nurses" may be of advantage to the young seedlings; the natural reproduction of this species continues to be under special investigation, and experimental plots have been under observation in numerous localities.

Eucalyptus.—The figures collected in the plantations of the Nilgiris show some astonishing results in the rate of growth of *Eucalyptus globulus* (Blue gum).

Mean annual increments of 527 cubic feet per acre per annum in the case of high forest and of 815 cubic feet in the case of 7-year-old coppice show that this species utilizes the productive capacity of the soil to the extent of forming in the case of coppice over 16 tons avoirdupois of wood in one year per acre. In the case of an average plantation, the initial expenditure amounts to Rs. 46 to Rs. 65 per acre (excluding value of land), the annually recurring costs to Re. 1 per acre, and the net receipts after deducting felling and carting charges to Rs. 70 per acre for 5-year-old crops, Rs. 331 for 15 year-old crops, and Rs. 592 for 25-year-old crops. These figures are calculated for coppice wood only, as the data available for high forest are insufficient to yield reliable results.

In the sylvicultural gardens.—Experiments are in progress for testing the regeneration of important species, both natural and artificial, in dense shade and in the open, and in moist patches; sowing combined with the cultivation of field crops is being tried; experiments in the best method and time of collection of seed and continued tests in the fertility of seed from trees of different sizes are in progress, as well as observations on the percentage of germinative capacity. Various methods of nursery treatment, the beds being sometimes weeded and sometimes unweeded, varieties of direct sowing and transplanting, some beds being irrigated and some left dry, are under trial.

Developments in sylvicultural systems.—The publication of "Der Blendersaumschlag Und Sein System" by Wagner marks an advance in the regulation of the method of management by purely sylvicultural considerations, which is the longest step in this direction taken for some time.

Mr. M. R. K. Jerram published a note on the Group System in Germany and its application to Indian forests with special reference to *Pinus longifolia* in the Himalayas; the revision of the Murree-Kahuta Working-Plan in the Rawalpindi Division is now under consideration, and the prescriptions of the new working-plan may be expected to show signs of the influence of this report.

Opinion in the Punjab has for some time been decided in favour of a definite change of sylvicultural treatment for the coniferous forests of the Himalayan hills. The selection system, the first attempt at any regular method of management, has been modified to a removal of the yield by selection in groups, and some Forest Officers now advocate the adoption of the group system in place of the selection system or any modification thereof. The question is a difficult one, and its ventilation by free discussion is to be desired. At the 1913 Punjab Forest Conference, an illuminating paper on the subject was read by Mr. B. O. Coventry, who also pointed out in his paper on the conditions necessary for obtaining natural regeneration in deodar forests:—"For practical purposes it may be assumed that the failure of natural regeneration is due to the accumulation of humus and other organic substances which have interfered with the proper aëration and drainage of the soil." It remains necessary to ascertain by experiment the best means of obtaining the desired conditions. The effect of drought and of the influence a seedling's position upon a steep or a very moderate slope may exercise upon its liability to prolonged cover by fallen snow appear also worth investigation.

The working-plans published during the year present no novel developments in the methods of management adopted.

Xylia dolabriformis.—A remarkable coincidence was the publication in the September 1912 number of the "Indian Forester" by Mr. R. S. Pearson of his observation that in the Western Ghats of Bombay, owing to continued protection from fire, moist deciduous forests were being replaced not at once by the true evergreen type, but by forests of which over 50 per cent. is made up of *Xylia dolabriformis;* while the next article was a statement from Mr. T. W. Forster that, in the Tharrawaddy Division of Lower Burma, fire protection and improvement fellings in combination had resulted in an almost regular forest of *Xylia dolabriformis* being formed from a mixed moist deciduous type.

List of Indian Publications, 1912-13.

AITCHISON, P. E.	. Working-plan for the Ankola-Kumta Coast Forests, Bombay Presidency.
,, ,,	. Working-plan for the Sopinhosalli High Forests, Bombay Presidency.
BILLSON, H. G.	. Working-plan for the Municipal Forests, Mussooree, United Provinces.
FORSTER, T. W.	. Natural Regeneration of *Xylia dolabriformis* in Tharrawaddy, Burma. (*Ind. For., xxxviii, 455.*)

GONSALVES, A. F. . Working-plan for the Igatpuri and Sinnar (Part) Range Forests, Bombay Presidency.

GRIEVE, J. W. A. . Working-plan for the Darjeeling Forests, Bengal.

JACOB, W. R. LEG. Report on the Forests of Bhutan bordering on the Boundary of Eastern Bengal and Assam, 1912.

JERRAM, M. R. K. . Report on the Group System of Natural Regeneration in Germany and its application to Indian Forests.

LEETE, F. A. . . Pyinmana Forest Division: Teak and Bamboos in Burma. (*Ind. For., xxxviii, 355.*)

LUSHINGTON, P. M. Note on the Coppicing Powers of Babul. (*Ind. For., xxxviii, 392.*)

MILROY, A. J. W. . Report on the Forest Resources of the Abor Country.

PARKER, R. N. . . Eucalyptus in North-West India. (*Ind. For., xxxix, 81.*)

SCOT, I. S. . . Coppicing of Babul in Guntur District, Madras. (*Ind. For., xxxviii, 396.*)

TROUP, R. S. . A Note on the Blue Gum Plantations of the Nilgiris (*Eucalyptus globulus*). (*Ind. For. Rec., v, Pt. II.*)

" " . . A Note on the Causes and Effects of the Drought of 1907 and 1908 on the *Sál* Forests of the United Provinces. (*For. Bull. No. 22, 1913.*)

" " . . The Collection and Tabulation of Statistical Data in the Sylviculture Branch, Forest Research Institute, Dehra Dun.

WHITEHEAD, J. . Working-plan for the Forests of the Jhansi and Banda Districts, Bundelkhand Division, United Provinces.

II.—ECONOMIC FOREST PRODUCTS.

BY

R. S. PEARSON, F.L.S.,

Forest Economist.

Economic uses of *sal* timber.—The enquiry into the uses, mechanical properties, seasoning qualities, outturn and prices of *sál* timber was completed during the year. It was found that though the durability of hill-grown *sál* is undoubtedly greater than that of the plains-grown varieties, their strength to withstand shearing, compression and transverse strain varies little. As regards the fissibility of the timber, coppice-grown varieties split more easily than those of seedling origin. The total annual outturn of *sál* timber was arrived at after considerable difficulty and was found to amount to 162,411 tons per annum of which 150,336 tons is obtained from Government Forests and the remainder from Native States and private lands. Of this total 38 per cent. is converted into railway sleepers, the remainder being used for construction and other purposes. As regards the price of *sál* timber it is a curious fact that though practically every species of timber has gone up in price during the last 20 years, as for instance that of teak, Deodar, Rosewood, etc., the price of *sál* sleepers has not advanced 10 per cent. during that period.

The results of the above enquiry are now being published, all points having been dealt with except those referring to the relative strength of timber cut at various periods of the year and the seasoning qualities of the same, the experiments in connection with which are not yet complete.

Bamboos for paper pulp.—The enquiry into the uses of bamboos for paper pulp was completed during the year and a report published on the subject. The idea of utilizing bamboos for pulp has of late been seriously considered by interested persons in India, so much so that one firm has been granted a concession to exploit bamboo from a forest in Bengal and another firm has applied for a similar concession in Burma and a third in Arakan. The industry, which is a new one, may in time develop into one of importance.

Antiseptic treatment of timber.—The enquiry as to the value of the antiseptic treatment of Indian timbers, with special reference to railway sleepers, was vigorously prosecuted during the year. The 2,929 Powellized sleepers of five different species of timber which were laid down as an experiment in the Sukkur, Quetta, Lakshar and Lucknow

sections of the line, about two years ago, were inspected and found to be doing well.

The 1,921 sleepers treated with *Avenarius Carbolineum* oil last year have now been laid down, with the exception of a small number still to be dealt with and which are destined to be laid in the line near Agra. The majority of sleepers treated with this oil, having been only recently put in the line, have not as yet been inspected, except those near Pyinmana in Burma.

During the year a third batch of sleepers, numbering 1,375 in all, were treated by a mixed impregnation method. This consisted in first forcing in a large quantity of a 2 per cent. solution of chloride of zinc and after the timber had time to dry, dipping them into a hot bath of green oil, the latter operation being carried out not only to preserve the wood, but also to prevent the salt from leaching out of the timber when exposed to excessive moisture. These sleepers are also being handed over to the Railway Board for laying in the open line.

A fourth batch of sleepers will be treated with Solignum and mineral oil, thus completing this enquiry, the only work remaining to be done being to periodically inspect the sleepers.

Tea-boxes.—A tour was made last year to enquire into the tea-box industry in Assam. One of the chief difficulties under which the tea-box saw-mills managers have to carry on their work is due to the impossibility of storing shooks against demand, owing to the deterioration of the timber and its liability to be attacked by borers. To overcome this difficulty experiments were carried out during the year at the Forest Research Institute, by treating the shooks with chloride of zinc, alum and copper sulphate solutions. It was found that the treated shooks affected the tea-lead with which they came in contact; this was overcome by either applying a coat of varnish to the inside of the shook or by placing brown paper between the lead and the shook or by using silverised paper instead of tea-lead. A further experiment is now being carried out in this connection with the co-operation of Mr. Blair, of the Surma Valley Saw-mills and an Assam tea-planter, by sending tea packed in treated shooks to Europe, with the object of ascertaining whether the tea is affected in any way. The other part of the enquiry consists in placing treated shooks in positions where they are liable to be attacked by insects. They have now been under observation for a year and so far they have not been damaged in any way.

Gums, resins and oleo-resins.—(*i*) A considerable amount of attention has been paid to the possibility of utilizing *Boswellia serrata* gum-resin. Experiments were carried out in order to ascertain the best methods of tapping the tree. These experiments were commenced last year, during the hot weather, very indifferent results being obtained; it was therefore considered necessary to try tapping in the cold weather.

A series of experiments were undertaken by the Divisional Forest Officers of Nimar and Melghat in the Central Provinces, by the Conservators of Forests in Gwalior and Kotah States and by the Forest Economist in the Siwaliks. It was found by all the officers in their various experiments that some trees yielded copious gum-resin while others yielded very little, the size and age of the tree having little to do with the yield obtained. It is proposed to carry out further experiments in this connection during the next cold weather in the Central Provinces in order to ascertain the best rotation for tapping, with special reference to the power of the tree to heal the wound caused by tapping it. The gum-resin of this tree was distilled by the Forest Chemist, turpentine, rosin, gum and an essential oil being prepared. These products were submitted to firms for valuation and the preliminary reports received justify further investigation being made.

(*ii*) A good deal of work was done in connection with the distillation of *Pinus longifolia* resin, resulting in the remodelling of the Government Rosin and Turpentine Factory at Bhowali.

(*iii*) The question of introducing into Europe the natural varnish obtained from *Melanorrhœa usitata* was under investigation, many firms having enquired about this commodity. The subject is still under investigation.

Tan barks.—The enquiry as to the possibility of utilizing certain tan barks for preparing tan extracts was continued and a good deal of information collected as to outturn, the Economist having carried out experiments in the Siwaliks to determine the yield of dry bark from *Terminalia tomentosa* and *Shorea robusta* trees of different girths. In the Central Provinces and in Sind the Conservators carried out extensive experiments to ascertain the yield of bark per acre of *Acacia arabica;* 30 tons of this bark have since been sent to the Raneegunge Tan Extract Factory for testing. The Divisional Forest Officer, Arakan, carried out similar experiments in Mangrove forests and felled a sample plot to ascertain the yield and cost of extraction of the bark, per acre.

Fibres.—Samples of fibre of *Bauhinia Vahlii, Helicteres Isora, Sterculia villosa, Trema orientalis, Urena lobata* and *Calotropis procera* were submitted to a home firm for valuation, some of the reports being encouraging. Enquiry was also made in this connection as to outturn and prices, while two Forest Officers, under the direction of the Conservator of Forests, Sind, carried out extremely interesting experiments with the object of determining the best methods of collecting and separating Calotropis fibre.

Miscellaneous uses of woods.—Samples have been supplied to firms for trial in connection with cement barrels, railway rolling stock, musical instruments, packing cases and for a variety of other purposes, the reports on which are awaited.

Economic and wood museums.—A considerable number of specimens were added to both museums, especially to the latter. A complete collection of specimens of teak from all forests of India and Burma was formed and also one of all timbers used for tea-boxes. A collection of large specimen planks representing the better known timber-species of commercial value is gradually being formed, valuable additions having been recently made to the collection.

Timber and minor product specimens.—A very large number of specimens, chiefly of timbers, were supplied by the Forest Department to various Government Departments, private persons and firms in India, Australia, America and Europe.

List of Publications and Articles on Forest Economic matters published during 1912-13.

BENSON, H. K. . Chemical Treatment of Waste Wood Recovering Values of Low Grade Material. (*Scientific American, June 7th, 1913.*)

COOMBS, F. A., & HARRISON, R. G. The Mangrove Bark of North Queensland and the Manufacture of Mangrove Cutch. (*Journ. Soc. Chem. Ind., Vol. XXXI, 212.*)

DONALD, J. . . Notes on a Visit to a Rusha Oil Factory. (*Ind.* For., Vol. XXXIX, *149.*)

DUCHESNE, MARTIN COLLIER. English Timber: Its Markets, Value and Production. (*Surveyor's Institution, Transactions, Vol. XLX, Part III.*)

GOVERNMENT OF MADRAS Report on the Proposed Acetone Factory.

GROOM, PERCY . . Resin Ducts of *Pinus Gerardiana* and *Pinus Khasya.*

HOLE, R. S. . . Different forms of Pyinkado. (*Ind. For., Vol. XXXVIII, 461.*)

KARA, S. . . Banana and its Fibres. (*Cap., Vol. L, No. 1237, p. 78.*)

MACMILLAN, H. R. . Pulp-wood. (*Dept. of the Interior Canada, Forestry Branch, Bull. No. 30.*)

MOOR, BARRINGTON . Turpentining in Forests under Management. (*Amer. Forestry, Vol. XIX, 219.*)

PAREY, E. J. . Turpentine Standards. (*Chemist Druggist, Vol. LXXXI, 1,700, 52.*)

PEARSON, R. S. . Note on the Utilization of Bamboos for the Manufacture of Paper-pulp. (*Ind. For. Rec., Vol. IV, Part V.*)

,, ,, . Note on "Ligno Protector" as a possible means of Preventing Timber from Splitting while Seasoning. (*For. Bull. No. 13.*)

,, ,, . Note on the Tea-box Industry in Assam. (*Ind. For. Rec., Vol. V, Part I.*)

,, ,, . Note on Technical Properties of Timber with special reference to the behaviour of *Cedrela Toona* while Seasoning. (*For. Bull. No. 15.*)

,, ,, . A Further Note on the Relative Strength of Natural and Plantation Grown Teak in Burma. (*For. Bull. No. 14.*)

,, ,, . . Note on the Economic Value of *Shorea robusta* (Sál). (*In the Press.*)

PERKIN, M. F. . Turpentine and Turpentine Substitutes. (*Oil and Col. Tr. Journ., Vol. XLIII, 708.*)

PETERS, E. W. . The Preservation of Mine Timbers. (*U. S. Dept. of Agr. Bull. No. 107.*)

PURAN SINGH . Note on the Distillation and Composition of Turpentine Oil from the Chir Resin and the Clarification of Indian Rosin. (*Ind. For. Rec., Vol. IV, Part I.*)

,, ,, . . Note on the Preparation of Tannin Extracts, with special reference to those prepared from the Bark of Mangrove (*Rhizophora mucronata*). (*Ind. For. Rec., Vol. III, Part IV.*)

,, ,, . . Memorandum on the Oil Value of some Forest Seeds. (*Ind. For., Vol. XXXIX, 279.*)

RAITT, W. . . Report on Bamboo Pulp as a Material for the Manufacture of Paper. (*Ind. For. Rec., Vol. III, Part III.*)

,, ,, . . Report on Savannah Grasses as Material for Production of Paper-pulp. (*In the Press.*)

RAO, M. RAMA . Memorandum on the Tea-chest Industry in Travancore. (*Ind. For., Vol. XXXIX, 5.*)

RODGER, A. . . Note on *Gmelina arborea* timber. (*For. Bull. No. 16.*)

,, ,, . . Note on *Pterocarpus marsupium* timber. (*For. Bull. No. 17.*)

RODGER, A. . . . Note on *Terminalia tomentosa* timber. (*For. Bull. No. 18.*)

,, ,, . . . Note on *Lagerstrœmia lanceolata* timber. (*For. Bull. No. 19.*)

,, ,, . . . Note on *Ougeinia dalbergioides* timber. (*For. Bull. No. 20.*)

,, ,, . . . Note on *Anogeissus latifolia* timber. (*For. Bull. No. 21.*)

SURFACE, HENRY E. . Bibliography of the Pulp and Paper Industries. (*U. S. Dept. of Agr., For. Serv., Bull. No. 123.*)

TEESDALE, CLYDE H. . The Absorption of Creosote by the Cell Walls of Wood. (*U. S. Dept. of Agr., For. Serv., Cir. No. 200.*)

WEISS, HOWARD F. . Prolonging the life of Cross-ties. (*U. S. Dept. of Agr., For. Serv., Bull. No. 118.*)

WINSLOW, CHARLIE P. Commercial Creosotes, with special reference to Protection of Wood from Decay. (*U. S. Dept. of Agr., For. Serv., Cir. No. 206.*)

,, ,, Condition of Experimental Chestnut Poles in the Warren-Buffalo and Poughkeepsie-Newton Square Lines after Five and Eight Years' Service. (*U. S. Dept. of Agr., For. Serv., Cir. No. 198.*)

ZOOLOGY.

I.—GENERAL ZOOLOGY.

BY

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Superintendent, Indian Museum.

Introduction.

In the past years it has been customary to include in the report on zoology a brief statement as to all work with a direct bearing on India carried out outside the Indian Museum. This work has been, for some years past, increasing in bulk, and I have no means of obtaining official information as to its scope and objects until the results are published. It seems better, therefore, to confine any statement regarding it to the bibliography of published works. The present report deals only with zoological work carried out in the Indian Museum during the financial year 1912-13.

I.—General Progress, Zoological Section, Indian Museum.

The most important event of the year has been the occupation of the new laboratories and offices on the top of the main building facing Chowringhee. All the research collections that were in the old building, which has now been transferred entirely to the Geological Survey of India, have been removed and rearranged.

Opportunity was taken to sort out the whole of the unnamed marine material (except the Mollusca) into the proper classes and orders and in some cases families.

II.—Collections.

Mr. Kemp's zoological collections from the Abor country and those of the Surgeon-Naturalist to the Indian Marine Survey have perhaps formed the most important additions of a general nature to the zoological collection. Another important collection, however, is that made by Mr. Gravely with the assistance of Mr. S. P. Agharkar of the Elphinstone College, Bombay, in the Western Ghats. In all these cases many new species have been or are now being described on the basis of the new

material, while important additions have also been made to our knowledge of the distribution of already-known animals.

Since Lord Carmichael came to Bengal he has employed collectors to obtain the insects and other small animals of Sikhim and the Darjiling district. With great generosity His Excellency has arranged to distribute the specimens thus obtained to museums in India, Australia and Great Britain. On the abolition of Mr. Paiva's former post, he appointed him as his private assistant in arranging for the naming and distribution of the specimens. When Mr. Paiva was reappointed on the Museum staff, it was arranged by the Superintendent that he should continue to devote a certain part of his time to His Excellency's collections, which are now attaining great dimensions, in consideration of the fact that the Museum is to be allowed to retain any specimens that are required. Mr. T. Southwell has presented a very large and valuable collection of Entozoa together with some interesting crustacea.

Large additions have also been made by exchange with various Museums abroad and we have to thank our Honorary Correspondents and others for valuable specimens far too numerous to be acknowledged here specifically. Full acknowledgment will be made in various papers on different groups to be published in the "Records of the Indian Museum."

In March 1912, the Government of India made a special grant of £250 for the purchase of Mr. E. Green's collection of moths from Ceylon. This collection will be considered in next year's report.

As has already been pointed out, a large part of our zoological collection has been rearranged during the year. With the exception of the molluscs, on which a great deal of work is being and still remains to be done, all groups may now be said to be accessible to the student.

Mr. F. H. Gravely submits the following report on the entomological collections:—

ARACHNIDA, MYRIOPODA, AND INSECTA.

Arachnida.

"**Scorpionidea.**—Dr. Henderson has named the scorpions collected by the Abor Expedition. The scorpions which we sent to Dr. Penther have eventually been forwarded by him to Dr. Kraepelin, who has already named them. Most of these specimens are now on their way back to us, and the rest of our unnamed collection, as well as representatives of the named collection, have been sent direct to Dr. Kraepelin, who hopes to be able to return these specimens also before very long.

Chernetidea.—Mr. Elligsen has identified and returned our whole collection of Pseudoscorpions. Unfortunately his health broke down

shortly afterwards and he has not yet been able to publish his descriptions of the new species.

Araneae.—The spiders of the Abor Expedition have been sent to Dr. Banks for report. The rest of the collection has been arranged by Mr. Gravely in the room adjoining that in which it was previously kept, where it was impossible to give it adequate space. The identifications of all the named Mygalomorphae not seen by Mr. Hirst have been checked, and most of the Argyopidae have been named, as have also a few specimens belonging to other families. But it has not yet been possible to check and synonymise the determinations previously made in other families. A number of specimens have been added to the collection, especially in the family Argyopidae, for the males of the local species of which a special search is being made.

Phalangidea.—Dr. Rohwer continues to determine all Phalangids added to our collection.

Acari.—Professor Nuttall and Mr. Warburton continue to name ticks for us. Dr. N. Banks has the mites of the Abor Expedition.

Myriopoda.

Scolopendridae.—Several new species have been described by Mr. Gravely and added to the named collection.

Symphyla.—All our material has been sent to Mr. Bagnall for examination.

Other forms.—These are still being worked out by Dr. Silvestri.

Insecta.

Thysanura.—Dr. Silvestri is still working at this order for us.

Collembola.—Dr. Carpenter is working out the Collembola of the Abor Expedition.

Darmaptera.—Dr. Burr continues to identify all earwigs we are collecting.

Orthoptera.—Dr. Griffini has undertaken the report on the Abor Gryllacridae and Stenopelmatidae and has asked for the rest of our material in these families as well. This has been sent to him.

The Mantidae and Phasmidae of the Abor Expedition have been sent to Dr. Giglio-Tos and the Tettiginae of the expedition to Dr. Hancock. Mr. Leigh still has material of ours in connection with his work on the life histories of Mantidae and Phasmidae. The deaths of Mr. Kirby and Mr. Shelford have unfortunately brought to an end the work of these investigators on our collections.

Termitidae.—Dr. Silvestri still identifies termites for us.

Mallophaga.—Our material in this group is still in the hands of Professor V. L. Kellogg. We understand that he expects to return it to us very soon now.

Odonata.—Mr. Laidlaw is working out the dragon-flies of the Abor Expedition.

Neuroptera (sensu lato).—Nothing more has been received from Professor Needham as yet. The Neuroptera of the Abor Expedition have gone to Dr. Banks for identification.

Trichoptera.—Dr. Betten still has our unnamed Trichoptera.

Hymenoptera.—Dr. Rohwer has reported on the Hymenoptera Sessiliventres of the Abor Expedition and is now working out the rest of our material in this group; Mr. Claude Morley is still working out Hymenoptera Parasitica for us; Mr. Wheeler is working out our ants and has already sent in his account of the Abor collection.

Coleoptera.—Mr. Gravely has finished rearranging our Passalidae and his catalogue of them is in the press; Mr. Arrow is still working on our Dynastinae, Cetoninae and Rutelinae; and Dr. Gillett has undertaken the identification of our Coprinae. Dr. Horn still names Cicindelidae for us; M. Grouvelle is now dealing with our Paussidae, Rhysodidae, Nitidulidae, Trogositidae, Colydiidae, Cucujidae, Cryptophagidae, Lathridiidae, Mycetophagidae, Parnidae, Heteroceridae; Dr. Bernhauer with our Staphylinidae, Mr. Bickhardt with our Histeridae, M. Lesne with our Bostrichidae, Herr Schenkling with our Cleridae, Mr. Creighton-Wellman with our Meloidae, Herr Borchmann with our Lagridae and Aleculidae, Herr Krekich-Strassoldo with our Anthicidae, Mr. Maulik with our Chrysomelidae Cryptostomes, Mr. Gahan with our Longicorns, and Mr. Marshall with our Curculionids. Dr. Jordan has worked out all our Anthribiidae during the year. In addition to the above specialists who deal with our collections in certain groups as a whole, Dr. Kolbe is working out the Carabidae, Dr. d'Orchymont the Hydrophilidae, Herr Schenkling the Cleridae, Erotylidae and Endomychidae, Herr Wichmann the Scolytidae and Dr. Wagner the Apioninae of the Abor Expedition; while the Lampyridae of the Expedition have been named by M. Olivier and the remaining Malacodermata, together with Ptinidae, Bruchidae and Anthicidae, by M. Pic.

Lepidoptera.—Captain Evans has worked out the butterflies of the Abor Expedition. He has also rearranged our collection of Satyrinae. During his visit to Calcutta further progress was made with the rearrangement and cataloguing of the Hesperidae, all identifications of which he checked last year. Examples of several Bornean species of Lycaenidae have been sent to Mr. Moulton for examination.

Diptera.—The whole of the collection of Diptera has been rearranged and an effort is now being made to catalogue it. Mr. Brunetti

continues his fruitful researches upon it and it is still growing rapidly. Dr. Kieffer is still working on our Chironomidae and Cecidomyidae, Miss Ricardo on our Tabanidae, Dr. Lichwardt on our Dolichopodidae and Nemestrinidae, Professor Bezzi on our Sapromyzidae and Dr. Speiser on our Diptera Pupipara. Mr. Edwards has recently undertaken work on our Culicidae.

Thysanoptera.—Our collection of Thrips is still with Mr. Bagnall.

Rhynchota.—Mr. Distant continues to return specimens to us as he names them. Mr. Rothschild has our Polyctenidae, and Mr. Van de Goot our Aphidae. We are still in communication with Mr. Green about Coccidae and with Mr. Crawford about Psyllidae."

III.—Public Galleries.

There can be no doubt that the public galleries of the Zoological Section should be entirely re-arranged and renovated, if they are to be brought up to the level now demanded of museums in Europe and America. In order to undertake this work, however, it would be first necessary that an entirely new set of exhibition-cases be provided. This would mean the expenditure of many thousands of pounds and if it were to be undertaken in our present financial position would entail the total extinction of our scientific work. By considerable sacrifice of other interests we might possibly afford to buy one or two modern cases: these would make the rest look extremely shabby and the general effect in the galleries would be, for many years to come, incongruous and even less satisfactory than the present condition of affairs. I estimate the cost of placing the zoological galleries in a satisfactory condition on an average a lakh of rupees a gallery, that is to say, about six lakhs altogether.

On my deputation to Monaco last March I took the opportunity to examine with very great care the fittings, etc., of the new Oceanographical Museum there. From the report submitted to the Trustees on my return I may quote the following paragraph:—

> "The actual exhibits of marine animals in the Monaco Museum are much less extensive than those in our own galleries: with few exceptions, they are no better preserved: their scientific interest is no greater and their arrangement in the cases is, from a student's point of view, less satisfactory in that it renders it more difficult to find the specimens of any one group. But the general effect from an artistic point of view is beyond comparison with that of any scientific gallery in the Indian Museum, for the educational appeal of a museum gallery lies almost as much in the environment of the specimens as in the specimens themselves."

IV.—Field Work.

Mr. B. L. Chaudhuri visited Chaibassa in May 1912, in order to make enquiries about the distribution of land tortoises in that district. Although he did not obtain specimens, he was able to arrange with officers stationed at Chaibassa that further enquiries should be made. These resulted in the acquisition of a specimen of an interesting new species of *Geoemyda* (*Rec. Ind. Mus., Vol. IX, Part 2*).

In April 1912, Mr. Gravely made a tour in the Satara and Rathnagiri Districts in the Western Ghats, accompanied by Mr. S. P. Agharkar, Lecturer on Biology, Elphinstone College, Bombay. The object of this tour was to investigate the life history of the freshwater medusa *Limnocnida indica* and also to study the distribution of the freshwater fauna on the two sides of the Ghats. A number of interesting facts were noted and valuable specimens obtained in connection with both enquiries and much material of a miscellaneous nature was acquired. Two papers in the "Records of the Indian Museum," *viz.*, Messrs. Gravely's and Agharkar's "Notes on the habits and distribution of *Limnocnida indica*" and my own account of the freshwater sponges of the Malabar zone, are founded wholly or in part on the results of this tour.

Mr. Gravely also spent a few days in February 1913 in Chaibassa in order to search for *Limnocnida* in the streams of that district, which resemble those of the Western Ghats in many respects. He obtained no satisfactory evidence of the occurrence of the medusa in Chota Nagpur, but collected some interesting sponges and other specimens.

In the same month Mr. Kemp made a tour on the Indian shores of the Gulf of Manaar, for the first part of which he was accompanied by Dr. J. R. Henderson, Superintendent of the Government Museum, Madras, who assisted in a most generous manner with his deep knowledge of the marine fauna of the district. The results are of importance as illustrating the extraordinary richness of the Crustacean fauna of these parts of the coast of India at which suitable conditions prevail. They have not as yet been completely co-ordinated and therefore will be best considered in next year's report.

While on leave I spent six weeks in Palestine and Syria. The object of the visit was, if possible, to trace the genera of sponges, coelenterates and polyzoa characteristic of the fresh waters of India and tropical Africa northwards up the Jordan valley, should they prove to have a distribution in any way similar to that of the Jordan fishes, whose African affinities have long been known. Collections of other invertebrates, more particularly the crustacea, worms and mollusca, were also to be made. The results are now being published in the "Journal of the Asiatic Society of Bengal" and a first set of all the specimens, including a considerable number of types, is being presented to the Museum.

V.—Research.

The removal and re-arrangement of the collections have naturally interfered to some extent with the research work of the section, but a considerable amount has nevertheless been accomplished.

While in Calcutta I have continued my own work on the freshwater sponges of India and have completed an account of those collected in Palestine.

Mr. Kemp has completed and passed for the press his account of the Indo-Pacific Stomatopoda. He has also commenced work on the Onychophora and Crustacea Decapoda of the Abor Expedition.

Mr. Chaudhuri has worked out the fish collected by Mr. Kemp in the Abor country.

Mr. Gravely has continued his work on the Oriental Pedipalpi and Passalid beetles. He has completed a revision of the latter, which will be published shortly in the "Memoirs of the Indian Museum." In addition to entomological work, he has been through the flatworms of the order Temnocephaloidea in the collection and has described certain features of the anatomy of *Temnocephala weberi*, the only Indian representative of its family.

Mr. Ekendranath Ghosh, our new honorary assistant, has carried out, partly in the Museum and partly elsewhere, a detailed study of the anatomy of certain Rathouisiid slugs and also of the blind prawn *Typhlocaris galilea*.

Captain R. B. Seymour Sewell, Officiating Professor of Biology in the Calcutta Medical College, has continued in the Museum his investigations on the marine Copepoda. Apart from their theoretical importance, it is not too much to say that these investigations have added a new group to our collections, as there were no Indian species of the order named in our cases until Captain Sewell began to work out and arrange the Copepods in the townettings obtained by the "Investigator." As Surgeon-Naturalist he has also initiated the use of mid-water nets on board the survey ship. The results are already proving extremely rich in all groups of pelagic Crustacea, etc.

Mr. T. Southwell, Deputy Director of Fisheries, Bengal, has made use of our laboratories in his investigations into the parasitology of Indian fish and other vertebrates. The first paper in what we hope will be a long series on the Entozoa has been published by him in our "Records."

Mr. E. Brunetti has continued his studies on the taxonomy and nomenclature of the Diptera. Amongst other work he has described the collection made by Mr. Kemp on the Abor Expedition.

List of Publications with special reference to Indian Zoology, from September 1912 to July 1913, prepared by B. L. Chaudhuri.

GENERAL.

ANNANDALE, N. . The African elements in the Freshwater Fauna of British India. (*Résumés des Communications, IX^e Congrès International de Zoologie, Monaco, Première Série, 29.*)

KEMP, S. W. . . Zoological Results of the Abor Expedition. Introduction. (*Rec. Ind. Mus., viii, 1.*)

,, ,, . . Preliminary Note on the Zoological Results of the Abor Expedition on the North-East Frontier of Assam. (*Résumés des Communications, IX^e Congrès International de Zoologie, Monaco, Troisième Série, 30.*)

LYDEKKER, R. . Biological Work in India. (*Nature, 90, 685.*)

PROTOZOA.

PATTON, W. S. . Studies on the Flagellates of the genera Herpetomonas, Crithidia and Rhynchoidomonas. (*Sc. Mem. by Officers of the Med. and Sanit. Depts., Govt. of Ind., No. 57.*)

PORIFERA (SPONGES).

ANNANDALE, N. . Freshwater Sponges of the Malabar Zone. (*Rec. Ind. Mus., vii, 386.*)

,, ,, . Porifera of the Abor Expedition. (*Rec. Ind. Mus., viii, 67.*)

COELENTERATA.

GRAVELY, F. H., & AGHARKAR, S. P. Notes on the Habits and Distribution of *Limnocnida indica*, Annandale. (*Rec. Ind. Mus., vii, 399.*)

ECHINODERMATA.

CLARK, A. H. . . The Crinoids of the Indian Ocean. (*Echinoderma of the Ind. Mus., Part vii.*)

VERMES.

LANE, C. . . *Trychostrongylus colubriformis* (*Giles*). (*Ind. Med. Gaz., xlviii, 129.*)

" " . . *Agchylostoma ceylanicum*, A new Human Parasite. (*Ibid., xlviii, 217.*)

SOUTHWELL, T. . Some Notes on Cestodes and other Parasites in Indian Fish. (*Deptl. Rec., Dept. of Agri., Bihar and Orissa, No. 1, 1912.*)

" " . On Some Trematode and Cestode Parasites from Fish. (*Rec. Ind. Mus., ix, 79.*)

STEPHENSON, J. . On a collection of Oligochaeta mainly from Ceylon. (*Spolia Zeylanica, viii, 251.*)

CRUSTACEA.

HENDERSON, J. R. . A new variety of freshwater crab from Travancore. (*Rec. Ind. Mus., ix, 47.*)

SEWELL, R. B. S. . Notes on the surface-living Copepoda of the Bay of Bengal. (*Ibid., vii, 313.*)

" " . The post-larval development of the Copepoda. (*Résumés des Communications, IX^e Congrès International de Zoologie, Monaco, Troisième Série, 24.*)

MYRIOPODA.

GRAVELY, F. H. . Two New Species of *Scolopendridae*. (*Rec. Ind. Mus., vii, 415.*)

" " . . *Scolopendridae* of the Abor Expedition. (*Rec. Ind. Mus., viii, 69.*)

HIRST, S. . . On a second Indian Species of the genus *Termitodesmus*. (*Ann. Mag. Nat. Hist., xi, 481.*)

INSECTA.

ARROW, G. J. . . Notes on the Lamellicorn genus *Popilha* and descriptions of some new Oriental species in the British Museum. [*Ann. Mag. Nat. Hist., xii (8th Ser.), 38.*]

BELL, T. R. . . The Common Butterfly of the Plains of India. (*Journ. Bomb. Nat. Hist. Soc., xxii, 92.*)

BEZZI, M. . . Indian Trypaneids (Fruit-flies) in the collection of the Indian Museum. (*Mem. Ind. Mus., iii, No. 3.*)

BICKHARDT, H. . *Histeridæ* (Coleoptera) of the Abor Expedition. (*Rec. Ind. Mus., viii, 121.*)

BLAIR, K. G. . . Some new Species of Indian Tenebrionidae. (*Ann. Mag. Nat. Hist., xii, 50.*)

BRUNETTI, E. . . New Oriental Diptera. (*Rec. Ind. Mus., vii, 445.*)

,, ,, . . Notes on the Life History of *Aphiochæta ferruginea*. (*Ibid., 515.*)

,, ,, . . Diptera of the Abor Expedition. (*Ibid., viii, 149.*)

,, ,, . . New Indian *Empidae*. (*Ibid., ix, 11.*)

,, ,, . . Diptera Nematocera (excluding *Culicidae, Cecidomydae* and *Chironomidae.*) (*Fauna of British India series.*)

BUGNION, E. . . Le Termes Horni Wasm. de Ceylon. (*Revue Suisse De Zoologie, xxi, 299.*)

BURR, M. . . Dermaptera of the Abor Expedition. (*Rec. Ind. Mus., viii,* **135.**)

CAMERON, P. . . On some new and other species of Hymenoptera in the collection of the Zoological Branch of the Forest Research Institute, Dehra Dun. (*Ind. For. Rec., iv, pt. ii, 1913.*)

CRAGG, F. W. . Studies on the Mouth Parts and Sucking Apparatus in the Blood-Sucking Diptera *Philæmatomyia insignis*, Austen. (*Sc. Mem., Offc. Med. Sany. Dept., Govt. Ind., No. 54.*)

,, ,, . . The Structure of *Hæmatopota pluvialis* (Meigen). (*Ibid., No. 55.*)

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ZOOLOGY.

II.—ECONOMIC ZOOLOGY.

PART I.—AGRICULTURAL ENTOMOLOGY

BY

A. J. GROVE, M.Sc.,
Officiating Imperial Entomologist.

Pusa Research Institute.—The investigations into the life-history and biology of injurious and useful insects were continued, the following being specially studied:—

1. Indigo Psylla { *Psyllopa punctipennis*, Crawford. (*Psylla isitis, Buck.*).
2. Painted Bug, (*Bagrada picta*, Fabr.).
3. Anar Butterfly (*Virachola isocrates*, Fabr.).
4. Termites, (*Termes* spp.).
5. Cotton Bollworms:
    - (*a*) *Earias fabia*, Stoll.
    - (*b*) *Earias insulana*, Boisd.
    - (*c*) *Gelechia gossypiella*, Saund.
6. Parasites of Cotton Bollworms:
    - (*a*) *Rhogas lefroyi*, Ashm. Ms.
7. Beetles attacking stored grain:
    - (*a*) *Calandra oryzæ*, L.
    - (*b*) *Rhizopertha dominica*, F.
    - (*c*) *Tribolium ferrugineum*, F. & T.
    - (*d*) *Æthriostoma undulata*, Motsch.
    - (*e*) *Silvanus surinamensis*, L.
8. Parasites of Castor Semilooper (*Ophiusa melicerte*, Dr.) and Cabbage White Butterfly (*Pieris brassicæ*, Linn.).
9. Sugarcane Fly (*Pyrilla aberrans*, Wlk.).
10. *Aleurodidæ.*

The investigation on Indigo Psylla which was taken up at the request of the Bihar Planters' Association was continued and an article on the results obtained was published in the *Agricultural Journal of India*, Volume VIII, Part I. The investigation into methods for the prevention of damage by insects in stored wheat has been taken up at the request of the Punjab Government and is being continued. The investigation is specially in connection with the Wheat Elevator which is to be erected at Lyallpur. The Cotton Bollworms (*Earias* spp. and *Gelechia* sp.) and their parasite (*Rhogas lefroyi*) have received very close attention this year with the idea of obtaining more accurate information of the relation between the parasite and its host, careful statistical records of the occurrence of the pest and its parasite having been kept.

Trials with European univoltine mulberry races have been continued. It has been found that the eggs are preserved quite satisfactorily if sent to a hill station for storage during the dormant period, this obviating the necessity of cold storage in a refrigerator which is very expensive. The hybridisation work with mulberry worms continues to give satisfactory results. Attempts have been made to make arrangements for the disposal of small quantities of eri cocoons produced by small rearers as the lack of some such arrangement has been a great obstacle in the way of extending the industry. Better organisation for the procuring of fresh disease-free seed is also wanted, and is under consideration.

The lac collections, with the exception of a few ranges, are now complete and the material collected is being arranged for submission to an Expert. The cultivation of lac for experimental and demonstration purposes has been continued.

In Apiculture attention has been mainly directed to obtaining fertilized queens from the European bees and experiments with the common Indian bee (*Apis indica*) in bar frame hives. The difficulties in the way of procuring fertilized queens are very numerous and although twenty-five queens were reared only two were successfully fertilized. However, a better understanding of the problem has now been obtained and further attempts will be made. The work with *Apis indica* was largely hampered by the lack of proper appliances, but these are being obtained, and the experiments will be continued.

Observations on peach flies have been continued by the Imperial Pathological Entomologist.

Provincial Departments.—In Madras the investigations upon the Deccan Grasshopper (*Colemania sphenerioides*) were continued. The observations included the study of parasites and other natural enemies, and the effect of deep ploughing upon the egg masses. A method for preventing damage to stored tobacco by the Cheroot Beetle (*Lasioderma*

serricorne) has been devised. Exotic cottons were again considerably damaged by the Cotton Stem Weevil (*Pempheres affinis*) and various experimental methods were tried, but with little success owing to the lack of knowledge of the life-history of the insect. A method was devised for preventing the collecting pots on toddy palms from the depredations of flies. Other pests dealt with included :—

Stenachroia elongella, Hmps.
Spodoptera mauritia, Bdv.
Nymphula depunctalis.
Euxoa segetis.
Azygophleps scalaris.
Antestia cruciata.
Leptocorisa varicornis.
Achœa melicerta.
Euplexia conducta.
Udaspes folus.
Earias insulana, *Earias fabia*, *Gelechia gossypiella*, *Stagmatophora coriacella*, *Dysdercus cingulatus*, *Oxycarœnus* sp., *Lecanium nigrum.*
Chilo simplex.
Diatrœa sp.
Aleurodes bambusœ.
Epacromia dorsalis.
Kumblihulas.
Pundaluoya simplicia.
Odontotermes sp.
Alcides leopardus.

In the United Provinces methods of preventing damage to potatoes by the potato moth (*Phithorimœa operculella*, Zell.) have been demonstrated. Observations have been carried out on the appearance of the parasite (*Rhogas lefroyi*) of the Cotton Bollworm (*Earias fabia*) in Bhindi and Cotton. Other pests dealt with included the Dusky Cotton Bug (*Oxycarœnus lœtus*, Kirby), the Cotton Leaf-roller (*Sylepta derogata*, F.) and the Rice Bug (*Leptocorisa varicornis*, F.). Demonstrations of methods of controlling insect pests were given at the Agricultural Shows with the help of show-cases and magic lantern lectures.

In Mysore, Green Bug of Coffee (*Lecanium viride*), insects attacking stored grains, and *Amsacto albistrigà* have engaged attention.

In Bengal, the following pests have been investigated :—

Rice Hispa (*Hispa œnescens*).
Rice Swarming Caterpillar (*Spodoptera mauritia*).

Mango Hairy Caterpillar (*Cricula trifenestrata*).
Tobacco Caterpillar (*Prodenia litura*).
Rice Caseworm (*Nymphula depunctalis*).
Rice Bug (*Leptocorisa varicornis*).
Jute Semilooper (*Cosmophila sabulifera*).
Jute mite (*Tetranychus* sp.).
Bihar Hairy Caterpillars (*Diacrisia obliqua*).
Moth Borer (*Chilo simplex*).
White moth borer (*Scirpophaga auriflua*).
Large brown cricket (*Brachytrypes achatinus*).
Mango shoot borer (*Alcides* sp.).
White Weevil (*Myllocerus* sp.).
Litchi mite (*Eriophyes* sp.).

In Burma, experiments with mulberry silkworms were not successful owing to the place in which they were reared being unsuitable. Among the crop-pests studied were the Swarming paddy caterpillar (*Spodoptera mauritia*), the Paddy caseworm (*Nymphula depunctalis*, the Paddy stem borer (*Schœnobius bipunctifer*), Mango weevil (*Cryptorhynchus gravis*, F.) and fruit flies. The effect of spraying with lead Arseniate for Chafer Beetles defoliating Gold Mohar trees was tested and also the use of light traps.

In the Punjab, attention has been specially directed to the Moth borer in Cane (*Chilo simplex*, Butl.), the cotton bollworm (*Earias* spp.) and its parasite (*Rhogas lefroyi*), the introduction of mulberry silkworm rearing among the Zemindars and testing of the effect of SO_2 and CO_2 upon wheat "weevil." With the moth borer (*Chilo simplex*) cutting out of the "dead hearts" has been found very effective in checking the damage done by the borer. The parasite (*Rhogas lefroyi*) of the cotton bollworms (*Earias* spp.) was successfully established in breeding plots at Lyallpur and parasite boxes distributed. The effect of sulphur dioxide is detrimental to the germinating capacity of the wheat and also bleaches it, though effective in killing the "weevil." The effect of CO_2 still requires further investigation as it is not effective in all cases upon the "weevil" and in some cases affects the germinating capacity of the wheat.

In Bombay, the chief pests dealt with were the leaf roller on Til (*Antigastra catalaunalis*), stem borer (*Chilo simplex*) in Jowar, Gram caterpillar on Tur (*Chloridea obsoleta*) and grubs attacking cotton.

In the North-West Frontier Province, attention has been specially directed to determining whether the Peach fruit fly is present there and it has been found that it appears rather late in the peach season, earlier fruits being completely free, but peaches left on the trees after

August 30th were affected by maggots. Peach Aphides have also proved a serious pest. Trap crops of Maize for sugarcane borer (*Chilo simplex*) have been very successful.

In the Central Provinces, experiments were made with the Maize as a trap crop for sugarcane borer.

In Bihar and Orissa the campaign against the Greasy Cut-worm (*Agrotis ypsilon*) was again successfully carried on. Experiments with storing potatoes against damage by Potato moth (*Phthorinia operculella*), demonstration godowns being started at various places.

In Baroda, methods of checking "Katra" (*Amsacta* spp.), Sesamum stem borer (*Oberea* sp.) and Cotton Bollworms (*Earias spp.*). Arrangements were made to commence the cultivation of lac on Babool trees.

The Indian Tea Association.—The Entomologist has been principally engaged in the study of Mosquito Blight on tea. Experiments have been made on the treatment of Mosquito blight, Red spider and various other insect pests of tea and the investigation of their parasites.

Southern Indian Planters' Association.—Experiments have been made in co-operation with the Government Entomologist, Madras, to investigate the rôle played by bees and other insects in the fertilization of coffee. *Heterasia cingalu* was found damaging tea in Nilgiri, Wynaad district. Experiments with Mosquito blight on tea were continued. *Lecanium viride* (Green bug) made its appearance in Coorg and Mysore.

II.—ECONOMIC ZOOLOGY.

PART II.—FOREST ENTOMOLOGY.

BY

C. F. C. BEESON, B.A.,*

Forest Zoologist.

Sal investigation.—The work has been confined to the United Provinces; Dr. A. D. Imms, Forest Zoologist, made a short tour in the *sál* forests of the Siwalik Division. The investigation of the late larva, the pupa and the imago of *Æolesthes holosericea* has now been completed.

* Dr. A. D. Imms held the post of Forest Zoologist up to the 27th February 1913, after which date, until the close of the year, Mr. N. C. Chatterjee remained in charge of the office.

The study of the eggs and early larval stages is being continued. A large number of male and female imagines and pupæ of *Æolesthes holosericea* was found in a felled trunk of *Terminalia tomentosa* in the Hoshangabad Forest Division, Central Provinces.

Three Bombycid moths bred from the larvæ attacking *sál* leaves received from Pilibhit Forest Division mentioned in last year's report were identified by Sir George Hampson as *Euproctis scintillans*, Wlk., or a species close to it.

The Coccinellid larvæ reported last year as predaceous upon Monophlebus scale insects have been identified by Mr. J. Weise as *Macronocius indicus*, sp. nov.

Lac investigation.—The work of studying the parasites of Butea lac has made considerable progress and nearly 2,000 specimens of such parasites have been reared up to date. These are gradually being worked out by various specialists abroad. Touring was undertaken during the year in three Forest Divisions in the Central Provinces and in the Rewah State, for the purpose of obtaining information regarding the local conditions and the frequent causes of failure of the lac crop. A biological study of the lac insect itself is now nearly complete, and it is hoped that this will serve to correct many of the errors prevailing with reference to the insect, and will be useful as a work of reference for all interested in lac cultivation, seeing that a reliable account of it does not at present exist.

Insects of several families were bred out of lac during the year and some of them are still awaiting identification by various specialists. The Coleopterous parasites of lac have been identified by Mons. A. Grouvelle of Paris as follows:—

Cathartus advena, Wlk.
Typhæa hercorea, L.
Cartodera asiatica, Grouv.
Holoparamecus kunzei, Anbi.
Crytophycus ceylonicus, Mos.
Silvanopsis Iyeri, Grouv.
Berginus maindroni, Grouv.
Tribolium ferrugineum, F.

Specimens of Butea stick lac were received from various Divisional Forest Officers of the Central Provinces, United Provinces and of the Khandesh Division, Bombay, and parasites are being bred out of them. The study of these parasites and their bearing on the production and propagation of lac is being continued.

In the winter brood the female lac insect is fertilised by winged and wingless males, but in the summer brood only the wingless form has been observed.

Indian Forest Records, Volume IV, Part II, containing descriptions of the new parasitic Hymenoptera bred from lac, by the late Mr. P. Cameron, was issued from the press during the year.

New species.—Among the specimens identified for us by specialists during the year the following have been described as new species:—

*1. *Ceratopogon lignicola*, sp. nov. (Chironomidæ).

*2. *Plecia impostor*, sp. nov. (Bibionidæ).

*3. *Parapleciomyia carbonaria*, gen. et sp. nov. (Bibionidæ).

*4. *Clitellaria bistriata*, sp. nov. (Stratiomyidæ).

*5. *Systœchus nivalis*, sp. nov. (Bombylidæ).

*6. *Hæmatopota albofasciatipennis*, sp. nov. (Tabanidæ).

†7. *Guadaba maculata*, sp. nov. (Cicadidæ).

A number of new species have been discovered by Dr. Ch. Kerremans (Buprestidæ), H. Gebien (Tenebrionidæ), Mr. Durrant (Tortricidæ), Mr. E. Meyrick (Microlepidoptera), Mr. Julius Weise (Coccinellidæ) and Mons. Grouvelle (Clavicornia), the descriptions of which are not yet published.

A Histerid beetle, *Platylister procerus*, Lew., collected at Dehra Dun, has hitherto been known from China only.

Other investigations.—(*a*) A species of Coccid attacking Chir pine in the Naini Tal Forest Division. The investigation was continued during the year, and a large part of the life-history of this insect has been ascertained. The insect has been sent to Professor R. Newstead for identification. Two species of Coccinellidæ, the larvæ of which are predaceous on these Coccids, have been determined by Mr. J. Weise as follows:—

1. *Exochomus uropygialis*, Muls.
2. *Nephus seocrini*, Ws.

(*b*) A study of the various species of termites found in the Indian forests. The work of collecting specimens of white-ants and notes relating to the damage done by them was continued, and specimens have been received from nearly all parts of India. A large number of specimens was sent to Professor Dr. F. Silvestri of Portici, Italy, for identification, but the work has been delayed by Dr. Silvestri's absence from Italy.

(*c*) Ipidæ attacking Blue pine (*Pinus excelsa*) and Chir pine (*Pinus longifolia*) in the Chakrata Forest Division. Dr. A. D. Imms, Forest

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* E. Brunetti—Indian Museum Records, Volume VII, Pt. V.

† W. L. Distant—Ann. Mag. Nat Hist., Volume X.

Zoologist, inspected the affected areas on a short visit in October 1912. The damage done was due to the following species:—

(1) *Tomicus longifolia*, Steb.
(2) *Polygraphus longifolia*, Steb.
(3) *Polygraphus major*, Steb.
(4) *Polygraphus minor*, Steb.
(5) *Scolytus deodara*, Steb.

Remedial measures were carried out in infested areas, but the effect of these is not yet observable.

Damage reported during the year.—(*a*) Caterpillars of Noctuid moth *Ophiusa tirrhaca*, Cram., and of Pyralid moths *Chalcidoptera straminalis*, Guer., and *Macalla moncusalis*, Wlk., attacking *sál* trees in the Morha Range of Kheri Forest Division.

There is no previous record of *Ophiusa tirrhaca*, *Cram.*, and *Chalcidoptera straminalis*, Guer., attacking *sál*.

(*b*) Ipidæ attacking *sál* trees in the Buxa Forest Division, Bengal.

(*c*) Caterpillars of a Pyralid moth belonging to the genus *Euzophera* or a closely allied one, attacking cones of Chilgoza pine in Zhob, Baluchistan.

(*d*) Coccids attacking Kail (*Pinus excelsa*) in Kamraj Forest Division, Kashmir State. It is believed that further observations will prove this attack to be similar to the one in Naini Tal Forest Division. It has also been noted to occur to some extent in Jaunsar, United Provinces.

(*e*) Bruchid beetles of the genus *Bruchus* attacking stored seeds of *Albizzia Lebbek* sent by the Sylviculturist.

(*f*) Microlepidopterous caterpillars attacking *sál* seeds in the Nowgong Division, Assam.

(*g*) A Lamiid beetle (*Glenea Spilota*, Thoms.) attacking Semal saplings (*Bombax malabaricum*) in the Kheri Forest Division, United Provinces.

(*h*) Caterpillars of a Microlepidopterous moth attacking Bamboo seeds in the North Thana Division, Bombay Presidency.

(*i*) Aphids attacking *Cryptostegia grandiflora* plants in Kangra Forest Division, Punjab.

Two species of Cleridae beetles predaceous on *Sinoxylon anale*, Les., and a variety of *Sinoxylon Crassum*, Les. (which attack Shisham, *Dalbergia Sissoo*, in Dehra Dun), have been identified by Dr. Schenkling to be *Tillus notatus*, Klug; and *Cylidrus cyaneus*, F.

Miscellaneous.—Help in the identification of various insects has been generously given by Sir George Hampson, Mr. G. J. Arrow, Mr.

C. J. Gahan, Mr. C. Morley, Dr. Malcolm Burr, Dr. Max Bernhauer, Dr. F. Silvestri, Mr. W. L. Distant, Mr. S. Hirst, Mr. E. Meyrick, Mr. G. Lewis, Mr. E. Brunetti, Dr. Ch. Kerremans, Mons. A. Grouvelle, Mr. Meade Waldo, Mr. J. Weise, Mr. Gebien, Dr. Schenkling, Dr. K. Jordan and others.

List of Publications on Economic Zoology.

Agricultural Research Institute, Pusa.	Directions for the cultivation of Eri Silk. (*Bull. No. 29.*)
Andrews, E. A.	Insects. (*Quarterly Journ., Indian Tea Association, 1912, Part 3.*)
	A parasite on the tea mosquito blight (belonging to family Mermithidæ). (*The Quarterly Journ., Indian Tea Association, 1913, Part 1.*)
Bainbrigge Fletcher, T.	Termites. (*Agri. Journ. India, July 1912.*)
	Note on a new Ant mimicking Beetle. (*Journ. Bomb. Natl. Hist. Soc.*)
	Life-history of Phasmid. (*Journ. Bomb. Natl. Hist. Soc.*)
	Life-history of *Coptosoma cribraria.* (*Journ. Bomb. Natl. Hist. Soc.*) Fleas on Horses. (*Agri. Journ. Ind., January, 1913.*)
Bainbrigge Fletcher, T., & Woodhouse, E. J.	Caterpillar pest of Mokameh Tal Lands. (*Agri. Journ. Ind., October, 1912.*)
Cameron, P.	On some new and other species of Hymenoptera in the collections of the Zoological Branch of the Forest Research Institute, Dehra Dun. (*Ind. For. Rec., Vol. IV, Part II.*)
Department of Agriculture, Assam.	Leaflet in English and Khasi on *Paintaphil*, a rice pest.
Department of Agriculture, Bengal.	Leaflets on :— 1. Pests of Sann hemp and how to check them. 2. The Jute Semilooper. 3. The Rice Stem-borer.
Department of Agriculture, Burma.	Bulletin No. 8 on the Cotton pests of Burma.
	Notes in Burmese papers on Rice Hispa, White-ants, Mga Mynaung Daung.

DEPARTMENT OF AGRICULTURE, MADRAS. Leaflet in English, Telegu and Kanarese on the Deccan Grass-hopper.

Leaflet in English and Tamil on Insect Pests.

Notes in Agricultural Calendar on Hairy Caterpillars (Kumblihula), Grasshoppers, Rice Bug and Insect Pests.

Leaflet in English and Canarese on the Flies spoiling toddy in South Canara.

DUTT, G. R. . . Life-histories of Indian Insect—Hymenoptera. (*Mem. Department of Agriculture in India, Entomological Series, IV, No. 4.*)

GHOSH, C. C. . . The Big Brown Cricket (*Brachytrypes achatinus*). (*Mem. Department of Agriculture in India, Entomological Series, IV, No. 3.*)

HANCOCK, J. L. . Tetriginæ (Acridinæ) in the Agricultural Research Institute, Pusa. (*Mem. Department of Agriculture in India, Entomological Series, IV, No. 2.*)

HOWLETT, F. M. . Yellow Fever and Mosquitos. (*Agri. Journ. of India, October, 1912.*)

INDIAN TEA ASSOCIATION. The Sandwich Caterpillar. (*The Quarterly Journ., Indian Tea Association, 1912, Part 1.*)

KASARGODE, R. S. . Two recent Agricultural Pests. (*Poona Agri. College Magazine, iv, No. 3, January, 1913.*)

LEFROY, H. M. . . The Psylla Disease of Indigo in Bihar. (*Agri. Journ. of India, January, 1913.*)

LEFROY, H. M., & FINLOW, R. S. An Inquiry into the Insecticidal action of some Mineral and other compounds on Caterpillars. (*Mem. Department of Agriculture in India, Entomological Series, iv, No. 5.*)

MAIN, T. F. . . A Series of Campaigns against the Rice Grass-hopper. (*Agri. Journ. of India, July, 1912.*)

MARSHALL, G. A. K. New species of Indian Curculionidæ. (*Ann. Mag. Nat. Hist., Vol. II, No. 62.*)

MISRA, C. S. . . Cultivation of Lac in the Plains of India. (*Bull. No. 28, Agricultural Research Intitute, Pusa.*)

Litchi Leaf-curl. (*Agri. Journ. of India, July, 1912.*)

WOODHOUSE, E. J. . Potato Moth in Bengal. (*Agri. Journ. of India, July, 1912.*)

VETERINARY SCIENCE.

BY

MAJOR J. D. E. HOLMES, M.A., D.Sc., M.R.C.V.S.,

Imperial Bacteriologist, Muktesar.

In compliance with the programme of research work approved for the year 1912-13, the following investigations were carried out:—

Rinderpest.—A series of experiments were made to discover more economical methods of manufacture and improved technique. The details have been submitted for publication in Memoir form.

Many experiments were made on the value of drug treatment in Rinderpest. This investigation is being continued. These experiments, so far, have given negative results. Many drugs and antiseptics were administered to infected cattle, but none had much appreciable influence in the course of the disease.

The Permanganate of Potash treatment, advocated by Major Walker, C.I.E., and under trial in the Punjab, proved to have no beneficial effect when administered to susceptible cattle.

Surra.—Further experiments were conducted on the treatment and transmission of Surra.

An attempt was made during the monsoon to carry out an investigation on certain questions connected with the transmission of Surra, by means of biting flies, on the Kathgodam-Ranikhet Road. The investigation was commenced, but had to be abandoned as there was no one available to continue the work. A further attempt is being made during the present year to continue this research with the aid of the Government Entomologist.

The Annual Report of the Bacteriological Laboratory in the Colony of Mauritius, for 1911, contains a report on the good results obtained in that Colony by the Holmes method of treatment for Surra. The results obtained on Bovidæ proved excellent. Of horses treated, 52·9 per cent. were cured.

The Divisional Veterinary Officer, Burma Division, Maymyo, records successful results with the same treatment among infected mules in Upper Burma.

Anthrax.—An investigation was made on the value of the simultaneous inoculations of an Anthrax vaccine and Anthrax anti-serum as compared with the inoculations of an unmodified virus and anti-serum.

The results show that the method under investigation confers an active immunity, but is open to the same objection as when virus is used, namely, that the results are irregular and in some cases deaths occur after vaccination.

A paper on the subject is being prepared for publication.

Hæmorrhagic Septicæmia.—The investigation regarding the vitality of the organism outside the body was continued and is not yet completed. The results, so far, point to the prolonged vitality of the organism under certain conditions in soil and to the probability of infection being conveyed through fodder and water.

A number of experiments were made on the drug treatment of this disease. The Permanganate of Potash treatment was found of no value. The treated animals died in the same time as the controls. One drug experimented with has given a certain measure of success when administered in the early stages of the disease.

This investigation is being continued.

Foot and Mouth Disease.—From 1st October 1912 to March 30th, 1913, the Imperial Bacteriologist was deputed, in addition to his other duties, to assist the Foot and Mouth Commission sent from England to study certain features of the disease in India. The Commission worked at the Branch Laboratory, Bareilly.

In addition to the sanctioned programme of research, the following subjects received attention.

Bursati.—A study was made of the etiology and histology of this disease. A paper on the conclusions is being prepared for publication.

Kumri.—The investigation of this disease was continued, but as yet no positive results have been arrived at. The disease is one which requires investigation at the seat of outbreaks and this cannot be done with the present staff.

Research from Veterinary Colleges and Provincial Laboratories.

From the Camel Specialist.—Mr. Leese continued his investigations into diseases of the camel and, in particular, the treatment of Surra. The results have been published as a Memoir of the Department of Agriculture, Veterinary Series, Vol. I, No. 3.

Bengal Veterinary College.—Mr. Ganguli, House Surgeon, and Mr. Mitter, Lecturer on Pathology, recorded the presence in Bengal of *Filaria Immitis* in dogs. Mr. Mitter further records the presence of Gastrodisc in an Indian Zebu and describes the occurrence of *Gnathostomum Spinigerum* in India.

A List of Papers published during 1912-13 bearing on Indian diseases.

BRANFORD, R. .	. Trypanblau in the Treatment of Canine Piroplasmosis as occurring in India. (*Vet. Journ., Vol. 68, pp. 643—648.*)
CROSS, H. E.	. The preparation of Anti-Rinderpest Serum by the injection of virulent Artificial Peritonial Fluid. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. II, pp. 206—215.*)
DUTT, J. F. D. .	. Successful treatment of Tetanus with Liquid Ferri Perchloride Fort B. P. (*Vet. Journ., No. 452.*)
GANGULI, H. C.	. Filaria Immitis in Calcutta. (*Vet. Rec., No. 1264 of 1912.*)
GILLET, E. S. .	. Hæmorrhagic Septicæmia in a horse. (*Journ. of Comp. Patho. & Thera., Vol. XXV, pp. 321.*)
HARTLEY, P. .	. On the Immune Bodies occurring in Rinderpest Immune Serum. Part I—The Preparation of the Rinderpest Immune Bodies by Dialysis of the Immune Serum. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. II, pp. 216—230.*)
,, ,, .	. Report on the Preparation of Rinderpest anti-serum by means of Diluted Virulent Fluids. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. II, pp. 231—241.*)
,, ,, .	. On the Immune Bodies occurring in Anti-Rinderpest Serum, and the Variations occurring in the Serum Proteins of Animals during Immunisation and Hyperimmunisation. (*Mem. of the Dept. of Agri., Vety. Ser., Vol. I, No. 4.*)
HOLMES, J. D. E.	. The Treatment of Surra in Horses by means of Arsenic and its Derivatives. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. I, pp. 1—48.*)
,, ,,	. The Cure of Surra in Horses by the Administration of Arsenic. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. I, pp. 49—72.*)
,, ,,	. A further note on the cure of Surra in Horses. (*Mem. Indian Civil Vety. Dept., No. 3 Pt. I, pp. 73—77.*)
,, ,,	. Some Experiments in the Treatment of Surra in Camels. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. I, pp. 78-97.*)

HOLMES, J. D. E. . Reports on Experiments carried out to test the susceptibility of Cattle for several districts and on Improved Methods of Rinderpest Serum Preparation. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. II, pp. 98—205.*)

" " . Further Testings of the H. S. anti-Serum and Vaccine on Bovines and Equines. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. III, pp. 242—247.*)

" " . The Practical Value of Authrax anti-Serum and Vaccines. Preliminary Report. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. IV, pp. 248—271.*)

" " . A Note on Elements resembling Spirochætes found in the Blood of Man and Animals. (*Mem. Indian Civil Vety. Dept., No. 3, Pt. IV, pp. 272—276.*)

" " . Anaphylaxis in the larger Animals. (*Mem. of the Dept. of Agr., Vety. Series, Vol. I, No. 1.*)

" " . Salvarsan in the Treatment of Surra in Horses, Dogs and Rabbits. (*Mem. of the Dept. of Agr., Vety. Series, Vol. I, No. 2.*)

" " . A Note on some Interesting Results following the Internal Administration of Arsenic in Canker and other Diseases of the Foot in Horses. (*Agr. Bull. No. 32.*)

" " . A Note on the M'Fadyean Staining Reaction for Anthrax Bacilli. (*Arg. Bull. No. 36.*)

" " . Some cases of Surra treated in the field and in the Laboratory during the Autumn of 1911. (*Mem. of the Dept. of Agr., Vety. Series, Vol. II, No. 1.*)

" " . A Description of the Imperial Bacteriological Laboratory, Muktesar: its Work and Products, English, Urdu and Hindi editions. (*Pamphlet.*)

LEESE. A. S. . . Some more successful Experiments on the treatment of Surra in the Camel with recommendations for Systematic treatment. (*Mem. of the Dept. of Agr., Vol. I, No. 3.*)

MITTER, S. N. . . Some Entozoa of Indian Elephants and a Gastrodisc (?) from an Indian Zebu. (*Journ. of Comp. Path. & Thera., Vol., XXV, Part 2.*)

" " . . A Brief Résumé of our knowledge of Rabies. (*Calcutta Med. Journ., Vol. VII, No. 5.*)

" " . . A Résumé of our knowledge on the occurrence of Gnathostomis Spinigerum in India and its relation to a similar parasite found in man. (*Vet. Journ., December 1912.*)

" " . . Further Note on a Gastrodisc (?) from an Indian Zebu. (*Vet. Journ., March 1913.*)

" " . . Filaria Immitis in Calcutta. (*Bull. de la Soc. de Path. Exot., Tome V, No. 9.*)

" " . . Descriptive Catalogue of Pathological Specimens in the Bengal Veterinary College Museum. (*Bengal Government Publications.*)

OLIVER, E. W. . . Note on Surra. (*Bull. No. 27 of Dept. of L. & A. of Agra & Oudh.*

" " . . Note on the Foot and Mouth disease of cattle in United Provinces. (*Bull. No. 24 of Dept. of L. & A. of Agra & Oudh.*)

WALKER, G. K. . . Rinderpest and Hæmorrhagic Septicæmia with Permanganate of Potash. (*Journ. of Comp. Path. & Thera., Vol. XXV.*)

WHITMORE, A. . . An Account of a Glanders-like disease occurring in Rangoon. (*Parasitology, Vol. XIII, No. 1.*)

MEDICAL RESEARCH WORK.

Work done under the auspices of the Indian Research Fund Association during 1912-13.

The following is a brief review of the work done under the control of the Scientific Advisory Board of the Indian Research Fund Association during the year 1912-13. The more important subjects dealt with were (1) Cholera, (2) Kala Azar, (3) Yellow fever, (4) Malaria.

(1) *Cholera.*—Major E. D. W. Greig, I.M.S., Assistant Director, Central Research Institute, Kasauli, was placed on deputation from the 26th January 1912 to conduct an enquiry into the disease. Calcutta was fixed as the centre of the investigation. His researches at Calcutta and at Puri at the time of the Car festival (which was attended by an outbreak of cholera) have already yielded results of very great interest and practical importance. He has demonstrated the important part played by the human "carrier" in the spread of infection.

(2) *Kala Azar.*—A sub-committee consisting of Surgeon-General Bannerman (President), Lieutenant-Colonel Donovan, Major Christophers and Dr. Bentley was formed to direct the enquiries. Captain F. P. Mackie, I.M.S., Captain Patton, I.M.S., and Dr. V. T. Korke were deputed for the purpose of carrying out the investigations. Captain Mackie has devoted most of his attention to Bengal and Assam and is at present working in the latter province. Captain Patton has been engaged chiefly in laboratory experiments investigating the insect transmission theory of the disease. Dr. Korke has devoted his time to the epidemiology of Kala Azar, studying the distribution and modes of spread of the disease in the endemic areas of Royapuram in Madras City. Their labours have added considerably to our knowledge of the disease, but much yet remains to be done.

(3) *Yellow fever.*—Major S. P. James, I.M.S., was deputed to study yellow fever in its endemic area with the object of drawing up a report as to measures for averting the danger of the introduction of the disease into India, and for stamping out the disease should it appear. Major James has returned and submitted an interesting and valuable report, which contains the opinion that the opening of the Panama Canal will not, immediately at any rate, increase the present danger of India becoming infected with yellow fever. Major James, however, points out that the increase in "local" trade that can be expected to follow the opening of the canal may modify materially the present distribution of the disease and so introduce new dangers which cannot at present be foretold. He advances reasons which lead him to believe that the main

trade routes are unlikely to be materially altered, and as they exist at present the chances of importing infected mosquitos are not considerable.

Meanwhile *stegomyia* surveys have been undertaken in Calcutta, Bombay, Madras, Karachi and Rangoon. The results demonstrate how widely diffused and universally present in the ports of India is *Stegomyia fasciata*, the mosquito responsible for the spread of yellow fever.

(4) *Malaria.*—On the inauguration of the Indian Research Fund, the Malaria Committee, already in existence, was made a sub-committee under the Scientific Advisory Board. Several grants were made to local Governments by the Research Fund during the year to enable them to carry out anti-malarial measures or surveys. Much useful work was done in this connection during the year.

On the recommendation of the Scientific Advisory Board grants were made by the Indian Research Fund during the year in aid of—

(1) Entomological Research in Pusa and at the King Institute of Preventive Medicine, Madras.

(2) Experiments on the subject of plague disinfection of rice in bulk which are being carried out at Parel, Bombay.

(3) Investigations into the chemical composition of milk in the United Provinces.

(4) The supply of scientific literature to brigade laboratories and for the Central Malaria Bureau.

(5) The extension and improvement of the Central Research Institure at Kasauli.

APPENDIX.

REPORT ON THE SCIENTIFIC AND TECHNICAL INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDED 30th JUNE 1913.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director, Imperial Institute.

The scientific and technical investigations which have been in progress at the Imperial Institute for India during the year ended 30th June 1913 are as follows:—

(1) **Opium and other drugs.**—A comprehensive report has been furnished to the India Office on the composition of Indian opium.

A sample of wild *Podophyllum Emodi* rhizomes from the North-West Frontier Province was of very satisfactory quality. These rhizomes would be considerably more valuable commercially than those of *Podophyllum peltatum* if they could be used in European medicine. At present, however, *P. Emodi* is not official in most pharmacopœias and can therefore only be employed for unofficial preparations.

An investigation of the alkaloids of *Peganum Harmala* seed has been carried out by Professor W. H. Perkin, Jr., with material supplied through the Imperial Institute. Copies of three papers on the subject, which he has contributed, in conjunction with Mr. R. Robinson, to the Chemical Society of London, are attached.

(2) **Essential Oils.**—A further report was furnished on the oil of "Nepal sassafras" or "Nepal camphor wood," *Cinnamomum glanduliferum.* The oil contains safrole, and might possibly be used as a substitute for sassafras oil, for which, however, there is only a limited demand, or as a source of safrole, or as a perfume for cheap soaps. For the latter purposes it would have to compete with camphor oil and would only realise about 4*d.* to 6*d.* per lb.

The scientific results of this investigation, conducted at the Imperial Institute, were communicated by Dr. S. S. Pickles to the Chemical Society of London, and a copy of his paper is attached.

A consignment of cuscus roots (*Vetiveria zizanioides*) from Trichinopoly was examined in order to determine the value of the material as a source of vetiver oil. The roots were found to be of inferior quality,

giving a low yield of somewhat abnormal oil, so that it was doubtful whether they would be readily saleable in Europe.

Samples of Kalamet wood (*Mansonia Gagei*) from Tenasserim contained very small amounts of volatile oil which could only be extracted with difficulty. Unless wood containing a higher percentage of oil can be obtained the material would probably not be of value for export.

Five samples of Cochin lemon-grass oil were examined, and suggestions were made as to the reasons for the change which has recently occurred in the character of the lemon-grass oil shipped from Cochin.

(3) **Turpentine Oil.**—Samples of turpentine oil from *Pinus excelsa* and *P. Khasya*, prepared by the Forest Chemist at Dehra Dun, were forwarded for examination. The oil of *Pinus excelsa*, after re-distillation to remove the yellow colour, was found to be equal in quality to the best grades of French and American turpentine oil. The oil of *Pinus Khasya* appears to be a mixture of terpenes, and would probably be classed in the market with low-grade American oil.

(4) **Oils and Oilseeds.**—The investigation of Margosa fat was continued in order to ascertain whether its unpleasant odour could be easily removed. It was found that the odour is due to the presence of a compound of sulphur, which apparently cannot be removed by means of solvents or by any simple or inexpensive process; it disappears when the fat is treated with steam, but subsequently develops again. The commercial utilisation of Margosa seed in Europe therefore seems impracticable at the present time.

A sample of Raina seed (*Amoora Rohituka*) yielded 43·5 per cent. of a viscous yellow-brown oil which would be of fair quality for soap-making, and on this basis the seed was valued at about £9 per ton in the United Kingdom (April 1913). A sample of "Panang" kernels (*Calophyllum Inophyllum*) yielded 71·4 per cent. of oil of good quality for soap-making, and a firm of oilseed crushers stated that kernels containing as much oil as this should be worth £16 per ton in the United Kingdom (April 1913).

Several sardine oils from the Fishery Bureau, Madras, were examined and found to be suitable for the usual purposes to which fish oils are applied, *viz.*, leather-dressing and currying, and to a smaller extent for soft soap manufacture, tempering steel, admixture with paint oils, and jute batching.

(5) **Burmese Lacquer.**—Samples of "Thitsi" or Burmese lacquer, forwarded to the Imperial Institute in order to ascertain the possibility of finding a market for the product in Europe, were submitted to manufacturers, merchants and technical chemists, several of whom expressed considerable interest in the material and undertook to carry

out trials with it. Some of the experiments were still in progress at the end of the year, but the majority of the experts consulted considered that Thitsi could not easily be utilised in the United Kingdom as a varnish, owing to its slowness in drying under ordinary conditions. In order to get the lacquer to dry satisfactorily it is necessary to expose it to a damp atmosphere at 30° to 35° C. for three or four days. A large firm of cabinet-makers, however, reported that they could use Thitsi in place of Chinese lacquer, and they were accordingly furnished by the Imperial Institute with the names of firms prepared to export it from Rangoon.

(6) **Fish Waste.**—Three samples of fish refuse from the Fishery Bureau, Madras, were found to contain average quantities of nitrogen, phosphoric acid and fat, but rather less protein than is usually present in fish meals. The material should be readily saleable as a fertiliser or for the preparation of feeding-stuffs.

(7) **Cotton.**—Fifty-two representative samples of the different types of cotton grown in the Northern Division, Bellary, were very similar in general characters and were, on the whole, of satisfactory quality.

Ten samples grown on the Government Experimental Farm at Akola, Central Provinces, consisted of good clean cotton of very satisfactory growth.

Eight samples grown experimentally at Lyallpur in the Punjab were of satisfactory appearance and strength, and were valued at good prices.

Several samples of cotton from Burma, including native types, Cambodia and "kidney" cottons, were also examined during the year.

(8) **Fibres.**—Three samples of rhea ribbons were forwarded by the Fibre Expert at Dacca for examination. Only one sample was sufficiently prepared to be saleable in Europe, and this was valued at £25 per ton in London by a firm of fibre merchants who expressed a desire to receive consignments.

A fibrous bark, stated to be derived from a species of nettle found in Terai and on the lower slopes of the Himalayas, would be suitable for paper-making, but for this purpose it would probably not be worth more than £4 or £5 per ton in the United Kingdom. It was suggested that possibly a useful fibre could be prepared from the plant by submitting the freshly cut stems to a retting process like that employed in the case of jute.

Four specimens of jute, grown experimentally, were specially examined at the request of the Fibre Expert at Dacca, in order to ascertain the percentage of cellulose present, the tensile strength, and the length of the ultimate fibres.

Samples of *Malachra capitata* and *Urena lobata* fibres grown experimentally were submitted for examination by the Fibre Expert at Dacca. Both fibres were of excellent quality, and were valued in London at prices above those of "first marks" Calcutta jute. The merchants stated that they would be glad to receive consignments of these fibres.

A sample of wild plantain fibre from Burma was of very good quality and was valued at about £20 per ton in London with "fair current" Manila hemp at £22 to £22 10*s*. per ton; a subsequent sample was valued at £35 per ton in London (May 1913) with "fair current" Manila hemp at £33 per ton. Commercial experts were of opinion that the fibre would be suitable for fine spinning, and there is no doubt that it would be readily saleable in the United Kingdom.

A small consignment of Sida fibre forwarded by the Fibre Expert at Dacca was sold in London at £27 per ton. It was however valued at £28 to £30 per ton (July 1912) if shipped in commercial quantities.

(9) **Rubber.**—Six samples of Para rubber from Burma were well prepared and exhibited good physical properties. They varied somewhat in composition, the amount of caoutchouc present ranging from 90·0 to 94·3 per cent. They were valued at about 3*s*. 2*d*. to 3*s*. 4*d*. per lb. in London with fine hard Para at 3*s*. 4*d*. per lb. (April 1913).

(10) **Miscellaneous Official Enquiries.**—In addition to the foregoing reports, information was furnished and assistance rendered during the year to Indian Government officials in connection with various technical and commercial matters, including the following:—

The utilisation of rice.

The analysis of feeding-stuffs.

The use of bamboo pulp as a paper-making material.

The marketing of sandalwood.

The determination of prussic acid yielded by beans.

The cultivation of peas and beans in Burma.

The production of "synthetic" timber.

The preparation of jute fibre.

A number of other miscellaneous enquiries relating to Indian matters received from commercial firms and private individuals in India and in the United Kingdom were also dealt with during the year, information being furnished to the enquirers regarding food grains, oilseeds, turpentine, tanning materials, fibres, minerals and various other subjects.

A number of articles and short notices relating to Indian economic products and their exploitation were published during the year in the

"Bulletin of the Imperial Institute." The principal subjects dealt with were as follows:—

"The Improvement of Cotton in India."

"Lemon Grass Oils from India."

"Turpentine Oils from India."

"Wild Plantain Fibre from India."

"The Occurrence of Samarskite in India."

INDEX.

A

B

N 2

C

D

E

F

G

H

I

J

K

L

M

P

R

S

T

V

W

X

Y

Z

Departmental Publications.

I.—METEOROLOGICAL DEPARTMENT.

Government of India Office.

(1) The Indian Daily Weather Report and Chart.

(2) The Weekly Rainfall Summary.

(3) The Monthly Weather Review.

(4) The Annual Summary.

(5) The Rainfall of India.

(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.

(2) Monthly Rainfall Tables and Summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.

(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.

(2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).

(2) Annual Summary.

(3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary }

II.—GEOLOGICAL SURVEY.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XLI, including the larger papers on geological subjects.

Records, Vols. XLIII, including the shorter papers and Annual Reports from 1868 to 1910, sold in parts, price one rupee each.

Manuals, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

III.—SURVEY OF INDIA.

(1) Annual General Report.

(2) Professional Papers.

IV.—BOTANICAL SURVEY AND ROYAL BOTANIC GARDEN, CALCUTTA.

(1) Annual Report of the Botanical Survey of India.

(2) Records of the Botanical Survey, Vols. I—VII.

(3) The Agricultural Ledger.—A series of papers on economic products issued as ready.

(4) Annual Report of the Industrial Section, Indian Museum.

(5) Annual Report of the Royal Botanic Garden, Calcutta.

(6) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII.

A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

V.—DEPARTMENT OF AGRICULTURE.

(1) Annual Report.—An account of the year's work of the Imperial Department, including the separate reports of the scientic officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).

(2) The Agricultural Journal of India.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) Scientific Memoirs of the Department of Agriculture.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

(4) Bulletin.—An occasional publication containing information on agricultural matters of a temporary nature.

(5) Leaflets.—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VI.—FOREST DEPARTMENT.

(1) Review of Forest Administration in British India by the Inspector-General of Forests (issued annually).

(2) Annual Progress Report of Forest Administration in each Province.—Issued by the Local Governments annually.

(3) Indian Forest Records.

(4) Indian Forest Memoirs.

(5) The Indian Forester.—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, published monthly.

(6) Bulletins are published from time to time.

VII.—ZOOLOGICAL DEPARTMENT.

(1) The Annual Report, 8vo.

(2) The Records of the Indian Museum, 8vo. Containing short papers on Indian zoology. One or two volumes issued annually in quarterly parts.

(3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.

(4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.

(5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

VIII.—Civil Veterinary Department.

(1) Annual Report.